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THE SACRED BEETLE.

[*Frontispiece.*

INSECT LIFE

SOUVENIRS OF A NATURALIST

J.-H. FABRE

DOCTEUR ÈS SCIENCES

'that inimitable observer.'—CHARLES DARWIN

TRANSLATED FROM THE FRENCH

BY THE

AUTHOR OF 'MADEMOISELLE MORI'

WITH A PREFACE BY

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To the attentive eye the sight of industrial insects exhibiting the most refined art in their labours is a spectacle both strange and sublime. Human Reason is confounded by Instinct thus raised to the highest pitch of which Nature can offer an example, and the perturbation of intelligence increases on observing, patiently and minutely, the details of the life of those creatures most highly en~~dowed~~ with instinct.

E. BLANCHARD.

First Edition 1901. *Reprinted* 1913

PREFACE

THIS little volume introduces the work of a great French naturalist to the reader of English. Réaumur, another Frenchman, is the greatest naturalist devoting himself to the observation of insects the world has yet seen. His six quarto volumes—*Mémoires pour servir à l'histoire des insectes*—were published between 1734 and 1742. J.-H. Fabre, who happily is still with us, is second only to Réaumur in this part of the great field of Natural History.

Though compatriots the two men are remarkably different in the nature of their genius. Réaumur, stately and slow, both discursive and diffuse. Fabre,—styled by Charles Darwin the immortal Fabre,—a most patient, indefatigable observer, ready to sacrifice everything to the carrying on of his work, but making deductions too rapidly from his observations, and taking a philosophical position from which he refuses to budge, even though he stand alone among the naturalists of this generation.

Fabre's great merit is his graphic portraiture of the living insect as it really is. This proves to be

very different from insect life as it is usually supposed to be by the uninstructed, and as it is only too frequently represented to be in books. In the volume now offered to the reader he is almost entirely concerned with the instinct of Hymenoptera, the highest of the insect world in this respect. His studies of this subject have been continued in several other volumes, and he has also included in the series the results of many years of observation of the habits of other and very different insects.

His philosophical position may be briefly stated to be a determined refusal to recognise evolution as a legitimate idea. In this we may think him wrong; but it must be admitted that his views form a valuable antithesis to those of the many evolutionists who take the position that all that remains for the naturalist to do is to repeat the words Natural Selection and variation, and declare that thereby we understand the Cosmos.

Fabre is a difficult writer to translate. Probably no one has ever written on this subject with equal brilliancy and vivacity. But he is the most Gallic of Frenchmen. If his words are literally translated, they scarcely make English; if freely translated, the charm of his diction is too easily missed.

We hope that this volume may induce the student to read Fabre's subsequent volumes.[1] Taken

[1] *Souvenirs Entomologiques* (Ch. Delagrave, 15 Rue Soufflot, Paris), of which there are now seven series, this volume being a translation of the first.

altogether they are, if not superior, at least not inferior to this one—preferred simply because it is the first of the series.

In his works there is a good deal of delightful autobiography. Starting as a child amidst the direst poverty, he has become a highly accomplished man, a great naturalist, a brilliant writer; and he he has done this with a complete contempt for money, and a great indifference to the other rewards that Society is ready to bestow for such work.

D. SHARP.

CAMBRIDGE, *20th August* 1901.

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THE SACRED BEETLE

THIS was how it came about. We were five or six, I the oldest and their professor, still more their comrade and friend; they, young fellows with warm hearts and lively imaginations, overflowing with that youthful vitality which makes one so open to impressions and so eager for knowledge.

Talking of one thing and another we followed a path bordered with elder and hawthorn, where already the Rose Beetle was revelling in the overwhelming scent of the clustering blossoms. We were going to see if the Sacred Scarabæus had yet appeared on the sandy plateau of Les Angles, rolling the ball of dung which ancient Egypt looked on as emblematic of the world; we wanted to discover whether the running stream at the bottom of the hill might not hide young newts under the net of water weeds—newts whose branchiæ look like tiny sprays of coral; to see if that elegant little fish of the rivulet, the stickleback, had donned his wedding cravat of azure and purple; if the new-come swallows were

dipping on pointed wings over the meadows chasing the midges which scatter their eggs in their airy dance; to see if the Eyed Lizard was sunning his blue-spotted body at the mouth of a hole made in the sandstone; or if the flocks of Laughing Gulls, come up from the sea after the legions of fish which ascend the Rhône to spawn, were hovering over the river, and now and again uttering their cry like the laugh of a maniac. But enough; suffice it to say that, like simple folk who find much pleasure in living with the brute creation, we were intending to spend a morning in enjoying the ineffable awakening of life in springtime.

We were not disappointed. The stickleback was in full dress, his scales would have made silver look dim; his throat was of the brightest vermilion. On the approach of a great horse-leech with no good intentions, up rose the spines on back and side as if moved by a spring. Thus bravely encountered, the bandit beat an ignominious retreat down among the water-plants. The dull race of molluscs, Planorbinæ, and water-snails were sucking in air on the surface of the water, and the great Water Beetle, with its hideous larva, went by wringing the neck now of one, now of another, without the stupid band seeming to notice it. But let us leave the waters of the plain and climb the steep cliff dividing us from the tableland where sheep are feeding and horses are being exercised for the approaching races, one and all bestowing largesse on the rejoicing dung beetles.

For here at work are the scavenger beetles to whom is entrusted the high office of clearing the

ground of impurities. It is impossible to admire sufficiently the variety of tools with which they are furnished, both to stir the dung with, to divide and shape it, and to hollow the deep retreats into which they shut themselves with their booty. These tools form a kind of technological museum, where there is a specimen of every kind of digging instrument. Some might be copied from those devised by human industry, others are of an original type, and might serve as models for new tools for man. Copris hispanica wears a strong horn on its head, forked and bent back, like the long spike of a pick-axe. To a similar horn C. lunaris adds two strong points, shaped liked a ploughshare, projecting from the thorax, and between them a sharp-edged protuberance, serving as a wide rake. Bubas bubalus and B. bison, both exclusively Mediterranean species, have foreheads armed with two stout, diverging horns, between which projects a horizontal share from the corslet. Geotrupes typhaeus carries three points on the front of its thorax, parallel and standing straight out, the middle one shorter than the others. Onthophagus taurus owns as implements two long curving appendages like the horns of a bull, while the furcate Onthophagus has a two-pronged fork on its flat head. Even those least well off have on one part or other hard tubercules—tools blunt indeed, but which the patient insect knows very well how to utilise. All are furnished with a shovel, *i.e.* a large, flat, sharp-edged head; all use a rake—in other words, they collect materials with their toothed front legs.

As compensation for their unpleasant work,

more than one gives out a strong scent of musk, and its ventral parts gleam like polished metal. Geotrupes hypocrita has the under part of its body bright with metallic lights of copper and gold, and G. stercorarius with amethystine violet. But the usual colour is black. It is in tropical regions that we find dung beetles in gorgeous array—absolutely living jewels. Under camel droppings in Upper Egypt is found a beetle rivalling the dazzling green of an emerald; Guiana, Brazil, Senegal, can show Copridæ of a metallic red, rich as the red of copper, bright as that of a ruby. If such a jewelled race be wanting to our country, still its dung beetles are not less remarkable for their habits.

What eagerness is displayed around a dropping! Never did adventurers from the four corners of the world show such eagerness in working a Californian claim! Before the sun grows too hot there they are by hundreds, large and small, pell-mell, of every kind and form and shape, hastening to secure a slice of the cake! Some work in the open air and rake the surface, some open galleries in the thickest part, seeking choice morsels, others toil in the under part and bury their treasure as soon as possible in the adjacent ground, and the smallest crumble some scrap fallen from the excavations of their strong fellow-workers. Some again—new-comers, and doubtless the hungriest—eat then and there, but the aim of the greater number is to lay up a store which will allow them to pass long days of plenty down in some sure retreat. A fresh dropping is not to be found just when wanted in a plain where no thyme grows; such a gift is

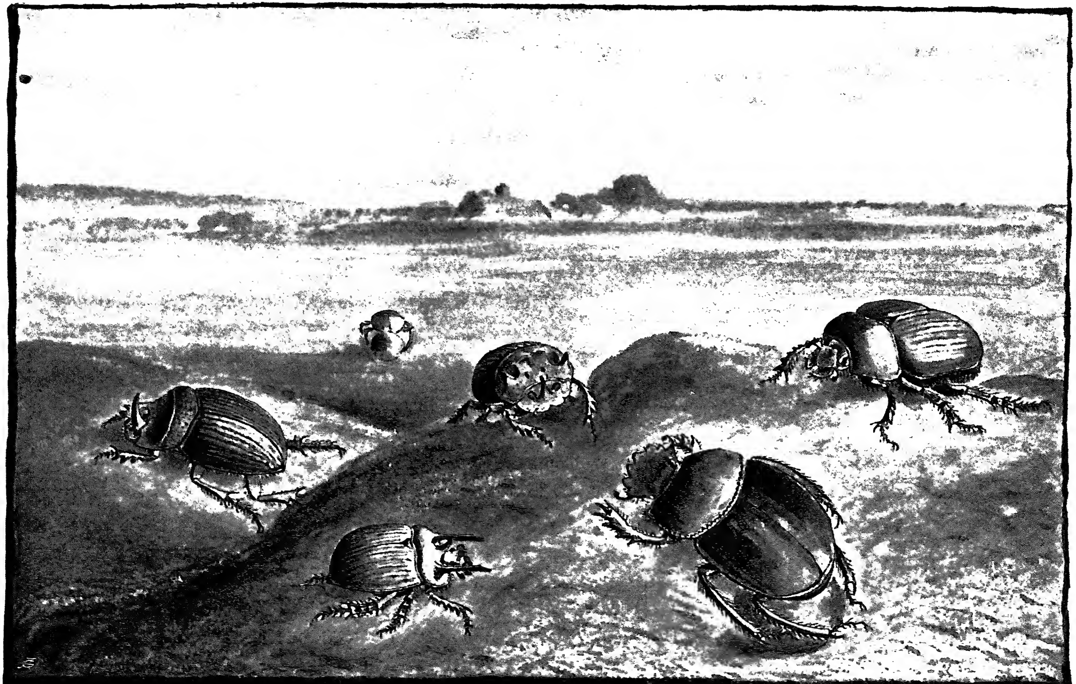
indeed a piece of good fortune, and only comes to the lucky. So when found, the wealth is prudently stored. The smell has carried the good news a couple of miles round, and all have rushed to gather up provender. Some laggards are still coming in on the wing or on foot.

What is the one now trotting towards the heap, fearing to arrive too late? His long legs work with a brusque, awkward action, as if moved by some machine inside him; his little red antennæ spread their fans—sure sign of anxious greediness. He is coming, has arrived, not without upsetting some of the guests. It is the Sacred Beetle, all in black, the largest and most celebrated of our dung beetles.

Here he is at table, beside his fellow-guests, who are giving last touches to their balls with the flat of their large front legs, or enriching them with a last layer before retiring to enjoy the fruit of their labours in peace. Let us follow this famous ball in each stage of construction.

The edge of the beetle's head is large and flat, and armed with six angular teeth arranged in a semicircle. It is the tool for digging and dividing, the rake to lift or reject such vegetable fibres as are not nutritious, to seek out what is best and rake it together. A choice is thus made, for these keen connoisseurs like one thing better than another—a somewhat careless choice, indeed, if the beetle alone be concerned, but one which is rigorously scrupulous if the maternal ball be in question, with its central hollow where the egg will hatch. Then every scrap of fibre is rejected, and only the quintessence of the stercoraceous matter is used to build the inner layer of

the cell. Then, as soon as it is hatched, the young larva finds in the walls of its dwelling a dainty food which strengthens digestion and enables it later to attack the coarse outer layers. For its own needs the beetle is less fastidious, contenting itself with a general selection. The toothed head hollows and seeks, rejects and gathers, somewhat at haphazard. The forelegs aid mightily. They are flattened, bent into the arc of a circle, are furnished with strong nerves and armed with five stout teeth. If an effort has to be made, an obstacle overthrown, a path forced through the thickest part of the heap, the dung beetle elbows its way; in other words, throws its toothed legs right and left, and clears a half circle with a vigorous sweep of its rake. Room being made, these same feet have a new task; they collect bundles of the material raked up by the head, and pass it under the insect to the four hind-feet. These are planned for the turner's trade. The legs, especially the last pair, are long and slender, slightly bent in an arc, and ending in a very sharp spur or talon. A glance shows that they form a spherical compass, capable of holding a globe in the bent legs to verify and correct its shape. In fact, their mission is to shape the ball. Bundle after bundle the material accumulates under the insect, held between the four legs which by a slight pressure lend it their own curve and something of shape. Then from time to time the rough hewn ball is set in motion between the legs of the double spherical compass, turned underneath the beetle, and rolled into a perfect sphere. Should the outer layer fail in plasticity and threaten to scale off, or if some



DUNG BEETLES GATHERING PROVENDER

[*To face p.* 6.

part be too fibrous, and refuse to be shaped by rotation, the faulty part is retouched by the forefeet; little taps of their broad surface give consistency to the new layer and imbed the recalcitrant fibre in the general mass. When the sun shines and work is urgent, one is amazed by the feverish activity with which the turner labours. Work goes on fast; first there was a pellet, now it is as large as a nut, by and by it will be of the size of an apple. I have seen some greedy beetles make up a ball as large as an apple. Assuredly there is food in the larder for some days to come!

Provender being gathered, the next thing is to retire from the *mêlée*, and carry it to a fitting place. Now we see some of the most characteristic habits of the Scarabæus. He sets out at once, embracing the ball with the long hind legs, whose talons, planted in the mass, serve as pivots—leans on the intermediary legs as pivots, and using as levers the flat of the toothed forefeet, which press the ground alternately, journeys backward with his load, the body bent, the head low, and the hinder part upraised. The hind feet, which are the chief organs in the mechanism, move continually, going and coming and changing the place where the talons are stuck in, to alter the axis of rotation, to keep the load balanced and advance by an alternate push right and left. Thus the ball comes in contact with the ground in every part of it, which gives it a perfect shape and lends consistency to the outer layer by a uniform pressure. Courage! it moves, it rolls, and the journey's end will be reached, though not without trouble. Here is a first difficulty. The beetle

has to cross a slope, and the heavy ball would naturally follow the incline, but for reasons best known to itself, the insect prefers to cross this natural slope—an audacious plan, which one false step or a grain of sand to upset the balance will defeat. The false step is made, the ball rolls to the bottom of the valley, and the insect, upset by the impetus of its load, staggers, gets again on its legs, and hastens to harness itself afresh. The mechanism works capitally. But look out, scatterbrain! follow the hollow of the valley, it will spare labour and misadventure. The road is good and quite level, and your ball will roll along with no exertion. Not a bit of it. The insect has made up its mind to remount the slope already so fatal to it. Perhaps it suits it to return to the heights. Against that I have nothing to say, the Scarabæus knows better than I do whether it be advisable to dwell in lofty regions. At all events, take this path which will lead you up by a gentle incline. Not at all. If there be near at hand some very stiff slope impossible to climb, then that slope this wrong-headed insect prefers. Then begins the labour of Sisyphus. With endless precautions the monstrous load is painfully hoisted, step by step to a certain height, the beetle always going tail first. One asks one's self by what miracle of statics such a mass can be kept on the slope. Ah! a clumsy movement brings all this toil to naught. Down goes the ball, dragging the beetle with it. The escalade is repeated, soon followed by a fresh fall. The attempt is renewed, and better managed at the difficult points; a nasty grass-root, which occasioned the previous tumbles, is prudently

turned; we have almost got to the top. But gently! gently! the ascent is perilous, and a mere nothing may ruin all. A leg slips on a bit of smooth gravel, and ball and scavenger roll down together. The beetle begins all over again, with tireless obstinacy. Ten times, twenty times, will it attempt that further ascent, until persistency vanquishes all obstacles, or until, better advised, it takes the level road.

The scavenger does not always roll his ball single-handed, but frequently takes a partner, or rather, a partner takes him. The affair is usually managed thus: the ball being prepared, a beetle comes out of the throng, pushing it backwards. One of the newcomers, whose own work is hardly begun, leaves its task and runs to the ball, now in motion, to lend a hand to the lucky proprietor, who appears to accept the proffered aid in an amiable spirit. The two work as partners, each doing its best to convey the ball to a place of safety. Was a treaty made in the workshop, a tacit agreement to share the cake? While one kneaded and shaped, was the other tapping rich veins whence to extract choice material for their common use? I have never observed such collaboration, but have always seen every beetle exclusively occupied by his own affairs on the field of labour, so that the last comer has no acquired rights.

Is it, then, an association of the two sexes, a couple about to set up house? For a time I thought so. The two scavengers pushing a ball, one before and one behind, with equal zeal, used to remind me of certain couplets once on a time popular on barrel-organs—

> Pour monter notre ménage, hélas comment ferons-nous ?
> Toi devant, moi derrière, nous pousserons le tonneau.

But the evidence of the scalpel forces me to give up this family idyll. There is no outward sign of sex in the Scarabæus, but on dissecting a couple employed on one and the same ball they often turned out to be of the same sex. In fact, there is neither community of family nor community of labour. What, then, is the reason of the apparent partnership? Merely an attempt at filching. The eager fellow-worker, under pretence of giving a helping hand, cherishes the project of carrying off the ball at the earliest opportunity. To make one for itself at the heap demands labour and patience; to abstract a ready-made one, or at least to foist one's self in as a sharer of the feast, is much more convenient. If the owner's watchfulness should slacken, one will flee with the treasure; if too closely looked after, one can at least sit down at table on the pretext of services rendered. With such tactics all turns to profit, so that pillage is carried on as one of the most lucrative of trades. Some, as I have just said, play an underhand game, hastening to the aid of some comrade who has not the least need of them, and under the cloak of charitable assistance conceal a highly indelicate greed. Others, bolder or more confident in their strength, go straight to the goal and rob by main force. Every moment some such scene as this will take place. A beetle departs alone, rolling his ball, his own property, acquired by conscientious labour; another comes flying, whence I know not, drops heavily, folds his smoky wings under their elytra, and with the back of his toothed feet oversets the proprietor, which, being hindside before, cannot defend itself. While the latter

struggles to its feet the aggressor stations itself on the top of the ball, as a point of vantage whence to repel attack, folds its feet under its breast, ready for action, and awaits events. The bereaved owner moves round the ball, seeking a favourable point whence to attempt an assault; the thief revolves on the top of the citadel, constantly facing him. If the former raises itself for an escalade, the latter gives it a cuff which stretches it flat on its back. Secure on the top of the fortress, the besieged would bring to nought for all time the efforts of its adversary to recover its lost property if the besieger did not alter his tactics. Sapping threatens to bring down both citadel and garrison. The ball being undermined, staggers and rolls, carrying with it the robber, struggling his hardest to keep at the top, which he generally succeeds in doing, thanks to the hurried gymnastics that enable him to regain the altitude lost by the rotation of his standing place. If a false movement should bring him to the ground, the chances become equal, and the contest turns to a wrestling match. Robber and robbed grapple body to body, breast to breast. Their feet twist and untwist, their joints intertwine, their horny armour clashes and grinds with the harsh sound of filed metal. Then one will succeed in throwing its adversary on the back, and, freeing itself, hastily takes up a position on the top of the ball, and the siege is recommenced, now by the robber, now by the robbed, as the chances of the fight may have decided. The former, no doubt a hardy brigand and adventurer, often gets the best of it. After two or three defeats the ex-owner wearies of the contest

and returns philosophically to the heap and makes a new ball. As for the other, when all fear of a surprise is over, he harnesses himself to the conquered ball and pushes it whither it seems good to him. I have occasionally seen a third thief rob the robber. And upon my word I was not sorry.

Vainly do I ask myself what Prudhon introduced into Scarabæus-morality the audacious paradox that "Property spells theft," or what diplomatist taught the dung-beetle that "they may take who have the power, and they may keep who can." I have not the evidence required to lead me to the origin of these spoliations which have become a habit, or of this abuse of strength in order to seize a ball of dirt. All that I can affirm is that among beetles theft is universal. These dung rollers pillage one another with a cool effrontery really matchless. I leave it to future observers to elucidate this curious problem in the psychology of animals, and return to the couple rolling their balls in partnership.

But first let us dissipate an error current in books. In the magnificent work of M. Emile Blanchard, *Metamorphoses, Habits, and Instincts of Animals*, I find the following passage: "Sometimes our insect is stopped by an insurmountable obstacle: the ball has fallen into a hole. At such a time the Ateuchus[1] displays a really astonishing grasp of the situation, and a yet more astonishing power of communication between individuals of the same species. Recognising the impossibility of getting the ball over the obstacle, the Ateuchus seemingly abandons it, and flies away. If you are sufficiently endowed

[1] The Scarabæus is also called Ateuchus.

with that great and noble virtue called Patience, remain near this forsaken ball. After a while the Ateuchus will return, and not alone; it will be followed by two, three, or four companions who, alighting at the appointed spot, will join in trying to lift up the load. The Ateuchus has been to seek reinforcements, and this explains why several beetles uniting to transport a single ball is such a common sight in dry fields." I also read in Illiger's *Entomological Magazine:* "A Gymnopleurus pilularius,[1] while constructing the ball of dung destined to contain its eggs, let it roll into a hole, whence the insect tried long and vainly to extract it. Finding this only waste of time, he hastened to a neighbouring heap of manure to seek three of his kind, which, uniting their efforts to his, succeeded in getting out the ball, and then went back to their own work."

I humbly beg pardon of my illustrious master, M. Blanchard, but assuredly things do not happen thus. First, the two accounts are so much alike that they must have had a common origin. After observations not followed up closely enough to merit blind confidence, Illiger put forward the story of his Gymnopleurus, and the same fact has been attributed to the Scarabæus because it really is a common thing to find two of these insects busy rolling a ball, or getting it out of some difficult position. But the partnership does not at all prove that one went to ask help from the other in some difficulty. I have had a large measure of the patience

[1] G. pilularius is a scavenger beetle nearly related to the Scarabæus. As its name suggests, it too rolls balls of dung. It is found very generally, even in the north, whereas S. sacer scarcely leaves the shores of the Mediterranean.

recommended by M. Blanchard; I may claim to have spent long days in the intimacy of Scarabæus sacer; I have tried every means to comprehend its manners and customs, and to study them from life, and never did I see anything which suggested that one had called its companions to its aid. As I shall presently relate, I have put the dung-beetle to proofs far more serious than that of a ball fallen into a hole, and into far graver difficulties than having to climb a slope—a thing which is mere sport for the obstinate Sisyphus, who seems to enjoy the rough gymnastics required by steep places, as if the ball grew thereby firmer, and therefore more valuable. I have invented situations where the insect had extreme need of help, and never could I detect any proof of good offices between comrades. I have seen pillaged and pillagers, and nothing else. If a number of beetles surrounded the same ball, it meant battle. My humble opinion is that several Scarabæi gathered round a pellet with intent to thieve was what gave rise to these stories of comrades called in to give a helping hand. Incomplete observations have turned an audacious robber into a serviceable companion who put his own work aside to do a friendly turn. It is no slight thing to admit that an insect has a truly surprising grasp of the situation and a facility of communication between individuals more surprising still; therefore I insist on this point, Are we to suppose that a Scarabæus in distress conceives the idea of begging for help?—flies off, explores the country round to find comrades at work on a dropping, and having found them, by some pantomime, especially by movements of the antennæ, addresses them more

or less thus: "Hullo, you there! My load is upset in a hole yonder; come and help me to get it out. I will do as much for you another time." And are we to suppose too that his colleagues understand him? And, more wonderful still, that they leave their work, their ball newly begun, their beloved ball, exposed to the greed of others, and certain to be filched during their absence, in order to help the supplicant! I am profoundly incredulous of so much self-sacrifice, and my incredulity is borne out by all which I have seen during many long years, not in collection boxes, but on the spots where the Scarabæi work. Outside of the cares of maternity—cares in which it almost always shows itself admirable, the Insect—unless, indeed, it lives in society like bees and ants and some others—thinks and cares for nothing but itself.

Let us drop this discussion, excused by the importance of the subject. I have already said that a Scarabæus, owner of a ball which it is pushing backwards, is often joined by another which hastens to its aid with interested views, ready to rob if it gets the chance. Let us call the pair associates, though that is hardly the name for them, since one forces itself on the other, who perhaps only accepts help for fear of worse. The meeting is, however, perfectly peaceable. The arrival of the assistant does not distract the proprietor for an instant from his labours; the newcomer seems animated by the best intentions, and instantly sets to work. The way they harness themselves is different for each. The owner of the ball occupies the chief position, the place of honour; he pushes behind the load, his

hind feet upraised, his head downward. The helper is in front, in a reverse position, head raised, toothed arms on the ball, long hind legs on the ground. Between the two moves the ball, pushed before it by the one, dragged towards it by the other. The efforts of the couple are not always harmonious, especially as the assistant turns his back to the road to be traversed, and the view of the owner is bounded by his load. Hence repeated accidents and ludicrous tumbles, taken cheerfully, each hastening to pick himself up and resume his former position. On level ground this style of draught does not answer to the expenditure of energy, for want of precision in combined movements; the Scarabæus behind would do as well or better alone, and the assistant, having proved his goodwill at the risk of disturbing the mechanism, decides to keep quiet of course without abandoning the precious globe, which he looks on as already his. A ball touched is a ball acquired. He will not be so imprudent as to let go; the other would instantly take advantage of it. So he folds his legs under him, flattens himself, incrusts himself, as it were, on the ball, and becomes part of it. Ball and beetle roll together, pushed along by the lawful owner. Whether it should go over the body of the other, whether he be above, below, or on one side of the rolling load, matters not—the intruder lies low. A singular helper this, who lets himself be run over for the sake of a share in the provender! But let them come to a steep incline, and he gets a chance of displaying his usefulness. On the steep slope he takes the lead, holding up the heavy load with his toothed feet while his

comrade steadies himself to hoist the load a little higher. Thus, by a combination of judicious efforts, I have seen them mount ascents, the one above holding up, the lower one pushing, where all the obstinate efforts of a single beetle must have failed. All, however, have not the same zeal in difficult moments; some, just when their assistance is most wanted on a slope, do not appear in the least aware that there is anything to overcome. While the unhappy Sisyphus is exhausting himself in efforts to surmount his difficulties, the other remains passive, incrusted on the ball, rolling down with it, and forthwith hoisted up again.

I have often tried the following experiment on two associates in order to judge of their inventive faculties in a serious predicament. Let us suppose them on level ground, the assistant firmly seated on the ball, the other pushing. Without disturbing the latter, I nail the ball to the ground with a long, strong pin; it comes to a sudden stop. The beetle, unaware of my treachery, doubtless believes in some rut, some dandelion root or pebble stopping the way. He redoubles his efforts, struggles his hardest, but nothing moves. What has happened? Let us go and see. Twice or thrice he walks round his pellet. Discovering nothing which can explain its immovableness, he goes behind and pushes again. The ball remains motionless. Let us look above. He climbs up to find nothing but his motionless colleague, for I have taken care to drive the head of the pin in deep enough to hide the head in the mass of the ball. He examines the summit and again descends; fresh thrusts are vigorously applied in

front and on either side with the same want of success. Certainly no scavenger beetle ever yet found himself confronted by such a problem of inertia. It is the very moment for claiming assistance, a thing all the more easy that the colleague is close at hand, squatted on the top of the dome. Will the Scarabæus give him a shake, or address him somewhat thus: What are you about, lazy bones? Come and look here; something has broken down. Nothing proves that he does so, for the beetle long persists in trying to move the immovable, examining now on this side, now on that, now above, now below, while his friend still remains quiescent. In the end, however, the latter becomes aware that something unusual is going on; it is brought home to him by the uneasy comings and goings of his companion and by the immobility of the ball, so in his turn he comes down to look into the matter. Double harness does not prove more effectual than single, and matters grow complicated. The little fans of their antennæ open and shut, open again, quiver and betray their lively anxiety. Then a stroke of genius ends their perplexities. Who knows what may be underneath? They explore below the ball, and a slight excavation reveals the pin. They recognise at once that the crux is there. Had I a voice in the matter I should have said, "An excavation must be made, and the stake which holds the ball must be got out." This very elementary proceeding, and one so easy to such expert excavators, was not adopted nor even attempted. The scavenger beetle was cleverer than the man. The two colleagues, one on this side, one

on that, insinuated themselves under the ball, which slipped up along the pin in proportion as the living wedges raised it, the softness of the material allowing of this clever manœuvre. Soon the ball was suspended at a height equal to that of the beetles' bodies. What remained to do was more difficult. From lying flat they gradually got on their legs and pushed upward with their backs. It was hard to accomplish, the feet losing strength the more they stretched upward, but they did it. Then came a moment when they could no longer use their backs to push, the highest point possible being reached. There was a last resource, but one much less favourable to the development of strength. Now in one of the postures in which it drags a ball, now in the other,—that is to say, either head downward or the reverse,—the insect pushes with hind or fore feet. Finally, unless the pin be too long, the ball drops to the ground. The perforation is repaired as best it can be, and the ball is at once dragged onward.

But if the pin should be too long, the ball remains suspended at a height which the insect cannot increase by rearing itself up. In this case, after vain evolutions around the inaccessible maypole, the beetles give up the struggle, unless you are kind-hearted enough to complete the work yourself, and restore their treasure, or unless you aid them by raising the floor with a little flat stone, a pedestal from whence the insect can continue its work. Its use does not seem to be immediately understood, for neither beetle shows any readiness to profit by it. However, by chance or otherwise, one gets on the stone. Oh, joy! as it passed it felt the ball touch its back.

Thereupon courage returns, and the struggle begins again. Standing on its platform the beetle stretches its joints, rounds its back, and hoists the pellet. When that no longer avails, it manœuvres with its feet, now upright, now head downward. There is a new pause and new signs of uneasiness when the limit of extension is reached. Without disturbing the creature let us put another little stone on the first. By the help of the new step, which gives a support for its levers, the insect pursues its task. Adding one step to another as required, I have seen the Scarabæus, perched on a shaky pile of three or four fingers' breadth, persisting in its labour until the ball was completely freed.

Had it some vague consciousness of the services rendered by the elevation of its point of leverage? I cannot believe it, although the beetle profited very cleverly by my platform of little stones, for if the very elementary idea of using a higher base to reach something too elevated was not beyond it, how was it that neither beetle bethought him of offering his back to the other, thus rendering the task possible? One assisting the other, they might have doubled the height attained. They are far indeed from any such combinations. Here, each pushes the ball with all its might, but pushes as if alone, without seeming to suspect the happy result which would be brought about by a combined effort. When the ball is fastened to the ground by a pin, they behave as they would when the ball is stopped by a loop of dandelion, or held by some slender bit of stalk which has got into the soft, rolling mass. My artifice brought about a stoppage not unlike

those which occur when the ball is rolling amid the many inequalities of the ground, and the insect acts as it would have acted in some circumstances where I had not interfered. It uses its back as a wedge and lever and pushes with its feet without at all varying its means of action, even when it might call a comrade to its help.

If it has to face the difficulties of a ball nailed to the ground with no assistant, its dynamic manœuvres are exactly the same, and it succeeds, so long as we give the indispensable help of a platform gradually built up. Should this help be refused, the Scarabæus, no longer stimulated by the touch of its beloved ball, loses hope, and sooner or later, no doubt with bitter regret, flies off, whither I know not. What I do know is, that it does not return with a squadron of companions whom it has implored to help it. What could it do with them, since it cannot utilise even the single comrade when one shares the ball? Perhaps, however, an experiment which suspends the pellet at a height inaccessible to the insect when its means of action are exhausted may be too much outside of ordinary conditions. Let us try a miniature ditch, deep enough and steep enough to prevent a beetle when placed at the bottom with its load from rolling it up. These are the exact conditions named by Blanchard and Illiger. What happens? When persistent yet fruitless efforts show the beetle that it can do nothing, it spreads its wings and flies off. Long, very long have I waited, on the faith of what these learned men say, expecting it to return with its friends, but I have always waited in vain. Often, too, many days later I have found the ball

just where I tried the experiment, either at the top of the pin or at the bottom of the hole, proving that nothing fresh had happened. A pellet abandoned from necessity is abandoned for good and all, without salvage by the help of other beetles. Dexterous use of wedge and lever to move the arrested ball is the highest intellectual effort I have ever seen in the Scarabæus sacer. As a counterpoise to what experiment refutes, namely, an appeal for help to brother beetles, I very willingly chronicle this feat of mechanics for the glorification of the Scarabæus. Straying over sandy plains thickset with thyme, ruts, and slopes, the ball is rolled for a while by the two partners, the material thus acquiring a firmness which they probably find palatable. By and by a favourable spot is selected. The proprietor, who has always kept the place of honour behind the ball and is the one who performs almost the whole work of draught, begins to hollow out the dining-room. Beside him is the ball, to which his associate clings, motionless. Head and toothed legs attack the sand, flinging quantities backward, and the excavation advances rapidly. Soon the insect disappears therein. Each time that he brings a load to upper air he never fails to glance at the ball to make sure that all is going on well. Now and again he brings it nearer to the edge of the cavity, feels it, and seems to gain new zeal from its contact. The other beetle, hypocrite that he is, continues to inspire confidence by his motionless attitude on the ball. Meanwhile, the underground hall grows larger and deeper, and the excavator appears more rarely, hindered by the extent of his labours. The moment is favourable,

the sleeper rouses up. The crafty partner decamps with the ball, dragging it behind him with the haste of a thief fearing to be caught in the act. This abuse of trust rouses my ire, but I let it pass in the interest of the story—time enough to interfere on behalf of morality if the upshot threaten to turn out ill.

Already the thief is some yards away. The robbed beetle comes up from his hole, looks, and finds nothing. No doubt he has himself had a hand in like proceedings. Scent and sight soon put him on the track and he hurriedly comes up with the robber, whereupon this sly dog promptly changes his position, gets on his hind legs and clasps the ball with his toothed arms as he does when acting helper. Ah, you rascal! I see through you! you would excuse yourself by declaring that the ball rolled down the slope, and that you are trying to stop it and take it home. I, however, who am an impartial witness, assert that the ball, being well balanced at the mouth of the hole, did not move of its own accord. Besides, the ground is level. I affirm that I saw you set it in motion and make off with unequivocal intentions. It was an attempt at larceny or I know nothing about it. My evidence not being taken into consideration, the owner listens mildly to his companion's excuses, and the two roll the ball back as if nothing had happened.

But if the thief can get far enough away, or can conceal his track by adroitly doubling back, the loss is irreparable. To have collected provisions under a fiery sun, to have conveyed them a weary way, to have hollowed out a comfortable banqueting hall in

the sand, and then, just when all is ready, and appetite whetted by toil lends charms to the prospect of the approaching feast, to find one's self suddenly robbed by a companion is certainly a reverse of fortune that would try most people's courage. But the dung beetle does not allow itself to be cast down by this malicious blow of fate; it rubs its cheeks, spreads its antennæ, sniffs the air, and flies to the nearest heap to begin again. This is a trait of character which I admire and envy.

Let us suppose the Scarabæus lucky enough to have met with a reliable partner, or, better still, that he has no self-invited associate. The hole is ready, made in friable earth, usually in sand, rather shallow, about the size of one's fist, communicating with the outer air by a short passage, just wide enough to let the ball pass. As soon as the provender is introduced, the Scarabæus shuts itself in, stopping up the mouth of the passage with fragments kept in reserve in a corner. Once the door is closed, nothing outside betrays the banqueting hall. And now hurrah! all is for the best, in the best of all possible worlds. The table is sumptuously laid, the ceiling tempers the heat of the sun, only allowing a gentle moist heat to penetrate; the calm, the darkness, the concert given by the field-cricket overhead, all favour digestion. Carried away by my interest, I have caught myself listening at the door, believing that I heard sung at table the famous

> Ah! how sweet 'tis nought to do
> When all around is endless stir.

from the opera of *Galathea*.

Who would dare disturb the beatitude of such a banquet? Alas! the desire for knowledge makes one capable of anything, and I have not shrunk from even this. I now give the result of thus violating the sanctity of home-life. The ball filled almost the whole space, the magnificent store of victuals rising from floor to ceiling, a narrow passage separated it from the walls. In this sat the banqueters, two at most, often but one, their faces to the table, their backs to the wall. When once they have taken their places nobody stirs, all their vital powers are absorbed by the digestive faculties. No little movement which might cause the loss of a mouthful, no daintiness which might waste the food — everything must be done decently and in order. To see them thus absorbed round a lump of dung, one would say that they were aware of their rôle as earth-cleansers, and consciously devoted themselves to that marvellous chemistry which out of impurity brings the flower that gladdens the eye, and the wing-cases of the Scarabæus which adorn the turf in springtime. To fit it for this all-important work, which turns into living matter the residue that horse and sheep cannot utilise, in spite of the perfection of their digestive organs, the dung beetle needs special tools. Accordingly anatomy shows the immense length of its intestine, which, folded repeatedly on itself, slowly deals with the material in its manifold circuits, and exhausts the very last atom capable of being used. Where the stomach of the herbivorous animal can extract nothing, this powerful alembic draws riches which under its influence become the ebony mail of the Scarabæus sacer, and a cuirass of gold and

rubies for other species. Sanitary principles require that this marvellous change be made as rapidly as possible; therefore the Scarabæus is endowed with a matchless power of digestion. Once shut up with food, it never ceases to eat and digest until the whole store is devoured. Proof of this is easily come by. Open the cell where it has retired from the world at any hour and you find the insect eating, and behind it, still attached to the creature, is a continuous cord, rolled carelessly like a bundle of cables. Without going into particulars, we can guess what this cord represents. Mouthful by mouthful the great ball passes into the digestive organs, yielding up its nutritive principle, and reappearing spun into a rope. Now this unbroken cord, often without a joint and always hanging from the orifice, proves, with absolute certainty, how continuous is the action of digestion. By the time that the food is nearly eaten, the rope is astonishingly long. Where else could one find another stomach, that, to avoid any loss in the debit and credit ledger of life, can feast for a week or a fortnight on such miserable cheer? When the whole mass has been digested, the hermit returns to daylight, seeks, finds, and shapes a new ball, and begins all over again. This royal life lasts one or two months, from June to July; then, with the coming of the fierce heat, which the grasshoppers love, the Scarabæi take up summer quarters and bury themselves in the cool earth. With the first rains they reappear, less numerous and less active than in spring, but apparently taken up by the all-important task of continuing their race.

If you seek among writers for information as to the habits of Scarabæus sacer in particular, and on the dung robbers in general, you find that science has not got beyond some of the beliefs current in the time of the Pharaohs. We are told that the ball which is dragged along contains an egg, and is a cradle where the larva will find board and lodging. The parents roll it over rough ground to make it round, and when shocks and shakes and tumbles all along the slopes have shaped it properly, they bury it and abandon it to mother earth.

So rough a start in life always seemed to me unlikely. How could a beetle's egg, so tender and fragile as it is, endure the rocking of its rolling cradle? There exists in the germ a spark of life which the slightest touch, the merest trifle, can extinguish, and is it likely that the parents should take it into their heads to lug it about over hill and dale for hours? Not they; maternal tenderness does not subject its progeny to the martyrdom of Regulus.

However, something more than logical reasoning

was required to sweep away received opinions. I therefore opened hundreds of balls rolled by the dung beetles and others out of holes dug under my eyes, and never, never did I find either a central niche or an egg in the pellets. They are invariably rough heaps of food, hastily shaped, with no particular structure inside them, merely provender with which the beetles shut themselves up to enjoy an orgy in peace for some days. They covet and steal them with an energy which they certainly would not show if it implied new family cares. It would be absurd for one Scarabæus to steal the eggs of another, each having enough to do in securing the future of its own. So on that point no more doubt can exist; the balls rolled by beetles never contain eggs.

My first attempt to resolve the thorny question as to the bringing up of the larva was by constructing an ample enclosure with an artificial soil of sand and soil constantly renewed. Some twenty Scarabæus sacer were introduced, together with Copris, Gymnopleurus, and Onthophagus, and never did entomological experiment cost me so many mortifications. The main difficulty was to renew the food. My landlord owned a stable and a horse. I gained the confidence of his servant, who first laughed at my plans, and then allowed himself to be gained over by a silver coin. Every breakfast for my beetles cost twopence halfpenny; never before did the budget of a scavenger beetle amount to such a sum. I can still see and shall always see Joseph, as, when after grooming his horse of a morning, he would raise his head a little above the wall between the two gardens and call "Heigh! heigh!" on

which I would hurry to receive a pot of manure. Discretion on both sides was necessary, as will be seen. One day his master appeared at the moment of transfer, and made up his mind that all his manure went over the wall, and that what he wanted for his cabbages went to grow my verbenas and narcissus. Vainly did I try to explain; my explanations seemed to him mere jests. Joseph got a sound scolding, was called this and that, and threatened with dismissal if it happened again. It did not.

I still had the resource of going bashfully along the road with a twist of paper to gather up stealthily provisions for my pupils. I did so, and do not blush for it. Sometimes fate was kind. A donkey carrying the produce of the market-gardens of Château-Renard and Barbentane to Avignon would depose an offering as he passed my door. Such a gift, instantly collected, enriched me for several days. In short, by hook or by crook, by watching for a dropping, or turning diplomatist to get one, I succeeded in feeding my captives. If success is earned by an experiment conducted with a fervour that nothing can discourage, my experiment deserved to prosper. It did not. After some time my Scarabæi, consumed by home-sickness in a space which deprived them of their wider movements, let themselves die miserably without revealing their secret. Gymnopleurus and Onthophagus responded better to my expectations. In due time I shall use the information furnished by them.

Along with my attempts at education in an enclosed space, I carried on direct researches, the

results of which were far from what I desired. I felt that I must have assistants. Just then a joyous band of children were crossing the high land. It was a Thursday, and oblivious of school and hated lessons, an apple in one hand and a piece of bread in the other, they were coming from the neighbouring village of Les Angles and wending their way to search on the bare hill where the bullets drop when the garrison is shooting at a mark. A few bits of lead, worth about a halfpenny, were the object of this early morning expedition.

The tiny rosy flowers of wild geranium enamelled the turf which for a brief moment beautified this Arabia Petrea; the water wagtail, half black, half white, uttered its scornful cry as it fluttered from one point of rock to another; on the threshold of burrows, dug at the foot of tufts of thyme, the field-crickets filled the air with their monotonous symphony. And the children were happy in this festival of spring—happier still at their prospective riches—that halfpenny which they would get in return for the bullets they would find, that halfpenny which would enable them next Sunday to buy at the stall set up before the church two peppermint bull's-eyes—two great bull's-eyes at a farthing apiece!

I accosted the tallest, whose wide-awake air gave me hopes of him; the little ones formed a circle, each munching his apple; I explained the matter and showed them Scarabæus sacer rolling his ball, and told them that in a like ball, buried somewhere, I knew not where, a hollow is sometimes found, and in this hollow a grub. The thing to be done was to

search about and watch the beetles in order to find such a ball. Those with no maggot would not count. To stimulate the children by a fabulous sum which would henceforward secure to me the time hitherto devoted to some farthing's worth of lead, I promised a franc, a lovely new coin worth twenty halfpennies, for each inhabited ball. At the mention of this sum eyes opened wide with delightful *naïveté*. I had quite upset their ideas on the subject of money by naming this exorbitant price as the value of a piece of dirt. Then, to show I was in good earnest, I distributed some halfpence to clinch the bargain. The following week at the same day and hour I was to appear at the same place and faithfully perform the conditions of our compact towards all who should have made the precious discovery. Having thoroughly posted up all the party, I dismissed the children. "He really means it!" they said as they went away; "he really means it! If we could only get one apiece!" and with hearts swelling with sweet hope, they clinked their pence in the hollow of the hand. The flattened bullets were forgotten. I saw the children scatter over the plain and hunt about.

On the appointed day the week after I returned to the tableland confident of success. My young helpers would no doubt have mentioned this lucrative trade in beetle-balls to their comrades and shown their handsels to convince the incredulous. Accordingly I found a larger party assembled than the first time. On seeing me they ran up, but there was no eagerness, no shout of joy. I saw that things had gone ill. Many times on coming out of

school had they sought for what I had described, but in vain. Some balls, found underground with the Scarabæus, were brought, but they were mere heaps of food, and there was no grub. Fresh explanations were given and a new appointment was made for the following Thursday. Again the same want of success. The seekers, discouraged, were now few. I made a last appeal, but nothing came of it. Finally, I paid the most zealous, those who had been faithful to the last, and we dissolved partnership. I could count on no one but myself for researches, which seemed simple enough, but really were exceedingly difficult. Even up to the present time, after many years, excavations made in favourable spots and hopeful opportunities have not yet given any clear, consistent result. I am reduced to combining incomplete observations and to filling up gaps by analogy.[1] The little which I have seen, together with observations on other dung beetles—Gymnopleurus, Copris, and Onthophagus—in my enclosure is summed up in the following statement.

The ball destined for the egg is not fashioned in public, in the hurry-scurry of the general workshop. It is a work of art and much patience, demanding minute care impossible amid a crowd. One must retire to meditate one's plans and set to work, so the mother makes a hollow from four to eight inches deep in the sand. It is a rather spacious hall, communicating with the outside by a much narrower gallery. The insect carries down choice materials, no doubt first rolled into pellets. She must make

[1] Fabre subsequently completed the whole life-history and published it in the fifth series of his *Souvenirs* (1897).

many journeys, for the contents of the hole are out of all proportion with the door, and could not be carried in at once. I recollect a Spanish Copris which, at the moment I came upon it, was finishing a ball as large as an orange at the bottom of a burrow only communicating with the outside world by means of a gallery where I could but just insert my finger. It is true that the Copris do not roll balls or make long journeys to fetch food. They dig a hole immediately under the dung, and crawl backward with successive loads to the bottom of their cavity. The facility for provisioning and the security offered by working under the manure favour a taste for luxury not to be expected in the same degree among beetles belonging to the rude trade of ball-rollers; but should it return two or three times, Scarabæus sacer can amass wealth of which Copris hispanica might well be jealous.

So far the insect has only raw material, put together anyhow. The first thing to do is to select very carefully, taking what is most delicate for the inner layers, upon which the larva will feed, and the coarser for the outer ones which merely serve as a protecting shell. Then around a central hollow which receives the egg the materials must be arranged layer after layer, according to their decreasing fineness and nutritive value; the strata must be made consistent and adhere one to another; and finally, the bits of fibre in the outside crust, which has to protect the whole thing, must be felted together. How can the Scarabæus, clumsy and stiff as it seems, accomplish such a work in complete darkness, at the bottom of a hole so full of provisions that there is

barely room to move? When I think how delicate is the work done and how rude the tools of the workman,—of the angular feet fitted to hollow the ground, and, if need be, even tufa,—I am reminded of an elephant trying to make lace. Explain who can this miracle of maternal industry; I give it up, especially as it has not been my good fortune to see the artist at work. Let us restrict ourselves to describing this masterpiece.

The ball which contains the egg is generally as large as a middle-sized apple. In the midst is an oval cavity about a centimetre in diameter. At the bottom is the egg, fixed vertically; it is cylindrical, rounded at each end, yellowish-white, about as large as a grain of wheat, but shorter. The wall of the hollow is washed over with a greenish-brown, semi-fluid matter, manure cream, destined as the first food of the larva. Does the mother collect the quintessence of the dung to make this delicate food? The look of it tells me that it is a pap prepared in the maternal stomach. The pigeon softens grain in its crop, and turns it into a kind of milk food which it disgorges for its nestlings. It would seem that the beetle shows the same tender care. It half digests the choice food, and disgorges it in the shape of a delicate film to line the walls of the cavity where the egg is laid. Thus, when first hatched, the larva finds food easy of digestion, which rapidly strengthens its stomach and allows it to attack the under layers which lack the same refinement of preparation. Under the semi-fluid paste is a choice pulp, compact and homogeneous, whence every particle of fibre is banished. Beyond are the coarser strata

where vegetable fibres abound, and finally the outside of the ball is composed of the coarsest materials felted together into a resistant shell. Manifestly there is a progressive change of diet. On issuing from the egg the feeble grub licks the fine paste on the walls of its dwelling. There is but little of it, still it is strengthening and of high nutritious value. To the bottle of early infancy succeeds the pap of the weanling, intermediate between the dainty fare of the start and the coarse nourishment at the end. This layer is thick enough and abundant enough to make the maggot into a robust grub. Then, strong food for the strong, barley bread with its husks, raw dung full of sharp bits of hay. The larva is superabundantly provisioned with it, and, having attained its growth, comes to the imprisoning outer layer. The capacity of the dwelling has increased with that of its inhabitant. The small original cavity with its excessively thick walls is now a large cell with sides only a few lines thick. The inner layers have turned into larva, nymph, or Scarabæus, as the case may be. In short, the ball is now a shell, hiding within its spacious interior the mysteries of metamorphosis.

My observations go no further; my certificates of the birth and condition of the Scarabæus do not go beyond the egg; I have not actually seen the larva which, however, is known and described by various authors. Neither have I seen the perfect insect while yet enclosed in the cell, previous to exercising its functions as ball-roller and excavator, and that is exactly what I should most have desired to see. I should have liked to find the

creature in its birthplace, recently transformed, new to all labour, so that I might have examined the worker's hand before it set to its tasks, and for the following reason.

Insects have each foot terminated by a kind of finger or tarsus, composed of a series of delicate portions which may be compared to the joints of our fingers. They end in a crooked nail. One claw to each foot is the rule, and this claw, at least in the case of the superior Coleoptera, especially the scavenger beetles, contains five joints. Now by a strange exception, the Scarabæus has no tarsi on its forefeet, while possessing well-shaped ones with five joints on the two other pairs. They are imperfect, maimed, wanting in their front limbs in that which represents, roughly indeed, our hand in an insect. A like anomaly is found in the Onitis and Bubas, also of the scavenger family. Entomology has long noted this curious fact without being able to give a satisfactory explanation. Is it a birth imperfection? Does the beetle come into the world without fingers on its front limbs, or does it lose them as soon as it enters on its toilsome labours?

One might easily suppose such mutilation a consequence of the insect's hard work. To grope, to excavate, to rake, to divide now among the gravel in the soil, now in the fibrous mass of manure, is not a work in which organs so delicate as the tarsi can be used without danger. Yet graver is it that when the insect is rolling its ball backward, head downward, it is with the end of the forefeet that it grips the ground. What becomes of the weak feet, no thicker than a thread, in this perpetual contact

with all the inequalities of the soil? They are useless—merely in the way, and sooner or later they are bound to disappear, crushed, torn off, worn out. Our workmen, alas! are too often maimed by handling heavy tools, and lifting great weights, and the same may be the case with the Scarabæus which rolls a ball that to it is a huge load. In that case the maimed arms would be a noble certificate of a life of toil.

But serious doubts at once suggest themselves. If these mutilations be accidental, and the result of laborious work, they should be the exception, not the rule. Because a workman or several workmen have had a hand crushed in machinery, it does not follow that all others should be maimed. If the Scarabæus often, or even very often, loses the fore-claws in its trade of ball-roller, there must be some which, cleverer or more fortunate, have preserved their tarsi. Let us then consult facts. I have observed a very large number of the species of Scarabæus which inhabit France, the S. sacer, common in Provence; S. semipunctatus, which is seldom found far from the sea, and frequents the sandy shores of Cette, Palavas, and of the Gulf of Juan; also S. longicollis, which is much more widely spread than the two others, and found at least as far up the Rhône Valley as Lyons. Finally, I have observed an African kind, S. cicatricosus, found in the environs of Constantine, and the want of tarsi on the fore-feet has proved invariable in all four species, at all events as far as my observations go. Therefore the Scarabæus is maimed from birth, and it must be no accident but a natural peculiarity.

Moreover, we have further proof in another reason. Were the absence of fore-claws accidental, and the consequence of rough labour, there are other insects, especially among the scavenger beetles, which undertake excavations yet more difficult than those of the Scarabæus, and which ought therefore to be still more liable to lose their front claws, as these are useless and in the way when the foot has to serve as a strong tool for excavation. For instance, the Geotrupes, who deserve their name of Earth-piecer so well, make hollows in the hard and beaten soil of paths among pebbles cemented by clay—vertical pits so deep that to reach the lowest cell one has to use powerful digging tools, and even then one does not always succeed. Now these miners *par excellence*, who easily open long galleries in surroundings whose surface the Scarabæus sacer could hardly disturb, have their front tarsi intact, as if to perforate tufa were a work calling for delicacy rather than strength. Everything then points to the belief that, if observed in its natal cell, the baby Scarabæus would be found mutilated like the veteran who has travelled the world and grown worn with labour.

On this absence of fingers might be based an argument in favour of the theories now in fashion—the struggle for life and the evolution of the species. One might say that the Scarabæus had originally tarsi on all its feet in conformity with the general laws of insect organisation. One way or another, some have lost these embarrassing appendages on their forefeet, they being hurtful rather than useful. Finding themselves the better for this mutilation,

which proved favourable to their work, little by little they gained a superiority over the less favoured ones, founded a race by transmitting their fingerless stumps to their descendants, and finally, the primitively fingered insect became the fingerless Scarabæus of our time. I am willing to agree to this reasoning if it could first be demonstrated why, with like labours,—labours even far harder,—the Geotrupes has preserved his tarsi. Meantime let us continue to believe that the first Scarabæus who rolled a ball, perhaps on the shores of some lake where bathed the Palæotherium, was as much without tarsi as him of our own day.

III

CERCERIS BUPRESTICIDA

EVERY one has met with books which, according to his turn of mind, have been epoch-making, opening to him horizons whose very existence he had never guessed. They throw wide open the gates of a new world where henceforward he will use his mental powers; they are the spark which, falling on a hearth, kindles into flame materials otherwise never utilised. And very often it is mere chance which puts into our hands some book which makes a new starting-point in the evolution of our ideas. The most casual circumstance, a few lines which happen to come under our eye, decide our future and impel us into the path which thenceforward we shall follow. One winter evening, beside a stove where the ashes were yet warm, while my family slept, I was forgetting, while I read, all the cares of the morrow—the black cares of the professor of physics, who, after having piled one university diploma on another and rendered for a quarter of a century services whose merit was not denied, earns for himself and family 1600 francs—less than a groom in a well-to-do household. Such was the shameful

parsimony of that day in educational matters; thus did Red tape will it. I was a free-lance, son of my solitary studies. Thus, amid my books I was putting aside acute professorial worries when I chanced to light on an entomological pamphlet which had come into my hands I forget how. It was by the patriarch of entomology of that day, the venerable savant Léon Dufour, on the habits of a Hymenopteron whose prey was the Buprestis. Certainly long ere this I had felt a great interest in insects; from childhood I had delighted in beetles, bees, and butterflies; as far back as I can recollect I see myself enraptured by the splendours of a beetle's elytra, or the wings of the great Swallowtail butterfly. The materials lay ready on the hearth, but the spark to kindle them had been lacking. The accidental perusal of Léon Dufour's pamphlet was that spark. I had a mental revelation. So then to arrange lovely beetles in a cork box, to name and classify was not the whole of science; there was something far superior, namely, the close study of the structure, and still more of the faculties of insects. Thrilled by emotion I read of a grand instance of this. A little later, aided by those fortunate circumstances which always befriend the ardent seeker, I published my first entomological work, the complement of Léon Dufour's. It gained the honours of the Institute of France, a prize for experimental physiology being adjudged to it, and—far sweeter reward!—shortly after I received a most flattering and encouraging letter from the very man who had inspired me. From far away in the Landes the venerated master sent me the cordial expression

of his enthusiasm, and urged me to continue my studies. At that recollection my old eyes still grow wet with a holy emotion. Oh, bright days of illusion, of faith in the future, what has become of you!

I hope that the reader will not be sorry to meet with an extract from the pamphlet which was the starting-point of my own researches, the more so that it is necessary for the understanding of what follows. So I will let my Master speak, only abridging slightly:—

In all insect history I know of no fact more curious and extraordinary than that which I am about to relate. It concerns a species of Cerceris which feeds its progeny on the most splendid kinds of Buprestis. Let me share with you, my friend, the vivid impressions gained by studying the habits of this Hymenopteron. In July 1839 a friend, who lives in the country, sent me two Buprestis bifasciata, an insect new to my collection, telling me that a kind of wasp which was carrying one of these pretty beetles had dropped it on his coat, and that a few minutes later a similar wasp had let fall another on the ground. In July 1840, having been called in as physician by my friend, I reminded him of his capture of the preceding year, and asked about the circumstances. Season and place corresponding with it, I hoped to do as much myself, but that particular day was dark and chilly, unfavourable therefore to the flight of Hymenoptera. Nevertheless, we made a tour of inspection in the garden walks, and seeing no insects I bethought myself of seeking in the ground for the homes of burrowing Hymenoptera. A tiny heap of sand recently thrown up, like a miniature mole-hill, attracted my attention. Scratching it away, I saw that it masked the orifice of a gallery descending far down. We carefully dug up the ground with a spade, and soon caught sight of the shining elytra of the coveted Buprestis. Soon I not only found wing-cases but a whole Buprestis, nay,

three and four displayed their gold and emerald. I could not believe my eyes. But that was only the prelude to my feast. In the chaos caused by my own exhumations a Hymenopteron appeared and was taken by me; it was the captor of the Buprestis, trying to escape from amid her victims. I recognised an old acquaintance, a Cerceris which I have found some two hundred times in Spain and around Saint Sever.

But my ambition was far from satisfied. It was not enough to know ravisher and prey: I wanted the larva for which all this rich store was laid up. After exhausting the first vein of Buprestis I hastened to make new excavations. Digging down more carefully I finally discovered two larvæ, which completed the good fortune of this campaign. In less than an hour I turned over three haunts of the Cerceris, and my booty was some fifteen whole Buprestids with fragments of a yet greater number. I calculated, and I believe it fell far short of the truth, that there were twenty-five nests in this garden, a fact representing an immense number of buried Buprestids. What must it be, I said to myself, in localities where in a few hours I have caught as many as sixty Cerceris on blossoming garlic, with nests most probably near, and no doubt provisioned quite as abundantly! Imagination, backed by probability, showed me underground, within a small space, B. bifasciata by thousands, although I who have observed the entomology of our parts for over thirty years have never noticed a single one. Once only, perhaps twenty years ago, did I see, sticking in a hole of an ancient oak, the abdomen and elytra of this insect. This fact was a ray of light, for it told me that the larva of B. bifasciata must live in the wood of the oak, and entirely explained the abundance of this beetle in a district where the forests consist chiefly of that tree. As Cerceris bupresticida is rare on the clayey hills of the latter stretch of country compared to the sandy plains where grows Pinus maritima, it became an interesting question whether this Hymenopteron when it inhabits the pine region provisions its nest as it does in

the oak district. I had good reason to believe that it did not, and you will soon see with some surprise how exquisite is the entomological tact of our Cerceris in her choice of the numerous kind of Buprestids.

Let us hasten to the pine region to taste new pleasures. The spot to be explored is a garden belonging to a property in the midst of forests of the maritime pines. The haunts of the Cerceris were soon recognised; they were exclusively found in the main paths, where the beaten and compact soil offered the burrowing Hymenoptera sufficient solidity for the construction of their subterranean dwellings. I visited some twenty, and I did it, I may say, by the sweat of my brow. It is a very laborious kind of exploration, for the nests and provisions are only found at the depth of one foot, so that it is necessary to invest the place by a line of square trenches seven or eight inches from the mouth of the hole, first inserting a stalk of grass in the gallery by way of clue. One must sap with a garden spade, so that the central clod, thoroughly detached all round, may be raised in one piece, then reversed on the ground and broken up carefully. Such is the manœuvre which I found successful. You would have shared our enthusiasm at the sight of the beautiful species of Buprestis which this new style of research revealed to our eager gaze. You ought to have heard our exclamations as each time the clod was reversed, new treasures were revealed rendered yet more brilliant by the hot sun, or when we discovered the larvæ of every age attached to their prey, or the cocoons of these larvæ incrusted with copper, bronze, and emerald. I who had been for three or four times ten years, alas! a practical entomologist had never beheld such an enchanting sight or had had such good fortune. We only wanted you to double our enjoyment. With ever increasing admiration we dwelt now on the brilliant Coleoptera and now on the marvellous sagacity of the Cerceris which had buried and laid them up for food. Can you believe it? Out of more than 400 beetles dug up, there was not one which did not belong to the old

genus Buprestis! Our Hymenopteron had not committed the smallest error. How much there is to learn from this intelligent industry in so small an insect! What value Latreille would have attached to the vote of this Cerceris in favour of the natural system![1]

Let us pass on to the various contrivances of the Cerceris in making and provisioning her nest. I have already said that she chooses ground whose surface is beaten, compact, and solid. I should add that this ground must be dry and in full sunshine. This choice shows an intelligence, or, if you like, an instinct, which one is tempted to believe is the result of experience. Crumbly earth or mere sand would of course be easier to work, but then how construct an orifice which will remain wide open for ingress and exit, and a gallery whose walls will not constantly fall in, yield, and become blocked by the least rain? The choice is therefore both reasonable and perfectly well calculated.

Our burrowing Hymenopteron hollows her gallery with her mandibles and front tarsi, which accordingly are furnished with stiff points to act as rakes. The orifice must not only have the diameter of the miner's body, but be able to admit a prey of larger bulk. This shows admirable forethought. As the Cerceris digs deeper she brings out the rubbish, and this makes the heap which I compared to a tiny molehill. The gallery is not vertical, as this would have exposed it to be filled up by wind or other causes. Not far from the starting-point it makes an angle; its length is from seven to eight inches. At the far end the industrious mother establishes the cradle of her progeny. Five cells, separate and independent of one another, are hollowed in the shape and nearly of the size of an olive; within they are solid and polished. Each can contain three Buprestids, the ordinary allowance for a larva. The Cerceris lays an egg amid the three victims, and then stops up the gallery with

[1] The beetles dug up belonged to the following species:—Buprestis octoguttata, B. bifasciata, B. pruni, B. tarda, B. biguttata, B. micans, B. flavomaculata, B. chrysostigma, B. novem-maculata.

earth, so that when once the provisions for the brood are laid in, the cells have no communication with the outside.

Cerceris bupresticida must be an indefatigable, daring, and skilful huntress. The cleanness, the freshness of the beetles which she buries in her den testify that they are seized just as they emerge from the wooden galleries where their final metamorphosis takes place. But what inconceivable instinct urges a creature that lives solely on the nectar of flowers to seek amid a thousand difficulties animal food for carnivorous offspring, which it will never see, and to post itself on trees quite unlike one another, which hide deep in their trunks the insects which are to fall her victims? What entomological tact, yet more inconceivable, makes her lay down a strict law to select them in a single generic group, and to catch species differing very considerably in size, shape, and colour? You observe how unlike are Buprestis biguttata, with its slender long body and dark colour; B. octoguttata, oval-oblong, with great stains of a beautiful yellow on a blue or green ground; and B. micans, three or four times the size of B. biguttata, with a splendid metallic greeny gold.

There is another very singular fact in the manœuvres of our assassin of Buprestids. The buried ones, like those which I have seized in the grasp of their murderers, give no sign of life, and are unquestionably quite dead, yet, as I observed with surprise, no matter when they are dug up, not only do they keep all their freshness of colour, but every bit of them—feet, antennæ, palpi, and the membranes which unite the various parts of their bodies—is perfectly supple and flexible. At first one supposes the explanation, as far as concerns the buried ones, to be in the coolness of the ground, and absence of air and light, and for those taken from their murderers, in the very recent date of death. But observe that after my explorations, having isolated in cones of paper the numerous Buprestids dug up, I have often left them over thirty-six hours before pinning them out. And yet, notwithstanding the dryness and great heat of July, I have always found the same

CERCERIS BUPRESTICIDA AND ITS PREY, BUPRESTICIS MICANS AND BUPRESTIS FLAVOMACULATA

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flexibility in the joints. More than this, after that lapse of time, I have dissected several, and their visceræ were as perfectly preserved as if I had used my scalpel on the live insect. Now, long experience has taught me that even in a beetle of this size, when twelve hours have passed in summer after its death, the interior organs are either dried up or corrupted so that it is impossible to be sure of form or structure. There is some peculiarity about Buprestids put to death by the Cerceris which prevents corruption or desiccation for a week, or perhaps two. But what is this peculiarity?

To explain this wonderful preservation which makes an insect dead for several weeks into a piece of game not even high, but, on the contrary, as fresh as when first caught, and that during the greatest heat of summer, the skilful historian of Cerceris bupresticida supposes that there must be an antiseptic liquid acting as do the preparations used in preserving anatomical specimens. This liquid can only be the poison injected by the Hymenopteron into the body of the victim. A minute globule of the venomous humour accompanying the dart or lancet, destined for this purpose, acts as a kind of pickle or antiseptic fluid to preserve the flesh on which the larva is to feed. But then how superior to our processes are those of the Cerceris with regard to preserved food! We salt or smoke or enclose in tins hermetically sealed provisions which remain eatable, to be sure, but which are far, very far from having the qualities of fresh meat. Sardines drowned in oil, Dutch smoked herrings, cod hardened into slabs by salt and sun,—can any of these sustain comparison with the same fish brought alive to the kitchen? For meat properly so-called it is still

worse. Beyond salting and drying we have nothing which even for a short period can keep meat eatable. At the present time, after innumerable fruitless attempts of the most varied kind, special ships are equipped at great cost, which, furnished with powerful freezing apparatus, convey to us the flesh of sheep and oxen slaughtered in the Pampas of South America, frozen and kept from corruption by intense cold. How far superior is the method of the Cerceris, so rapid, so cheap, so expeditious! What lessons we should have to learn from such transcendental chemistry when an imperceptible drop of liquid poison renders in an instant the prey incorruptible! What am I saying?—incorruptible?—that is far from being all; the game is put into a condition which prevents desiccation, leaves their suppleness to the limbs, and maintains all the organs in pristine freshness, both the internal and external. In short, the Cerceris puts the insect into a state differing only from life by a corpse-like immobility.

Such is the conclusion arrived at by Léon Dufour before this incomprehensible marvel of the dead Buprestis untouched by corruption. An antiseptic fluid, incomparably superior to anything that human science could produce, would explain the mystery. He, the Master, skilful of the skilful, thoroughly used to most delicate anatomy; he who with magnifying glass and scalpel has scrutinised the whole circuit of entomology, leaving no corner unexplored; he, in short, for whom the organisation of insects has no secrets,—can advance no better conjecture than an antiseptic liquid to give at least a kind of explanation of a fact which leaves him confounded. Let me

insist on this comparison between the instinct of the animal and the reason of the sage in order the better to demonstrate in due time the overwhelming superiority of the former.

I will add but a few words to the history of the C. bupresticida. This Hymenopteron, common in the Landes, as we have heard, seems to be rare in the department of Vaucluse. It is only at long intervals that I have met with it, in autumn, and always isolated specimens, on the spiny heads of Eryngium campestre, in the environs of Avignon or round Orange and Carpentras. In the latter spot, so favourable to burrowing hymenoptera, from its sandy soil of Mollasse, I had the good fortune, not indeed of being present at the exhumation of such entomological riches as Léon Dufour describes, but of finding some old nests which I feel certain belonged to Cerceris bupresticida, from the shape of the cocoons, the kind of provender stored up, and the existence of the Hymenopteron in the neighbourhood. These nests, hollowed in a very friable sandstone, called *safre* in those parts, were filled with remains of beetles, easily recognised, and consisting of detached wing-cases, empty corslets, and whole feet. Now these remains of the larva's feast all belonged to one species, and this was a Buprestis, Sphænoptera geminata. Thus from the west to the east of France, from the department of the Landes to Vaucluse, the Cerceris remains faithful to its favourite prey; longitude does not affect its predilections, a hunter of Buprestids among the maritime pines of the ocean sand-hills, it is equally so amid the evergreen oaks and olives of Provence.

The species is changed according to place, climate, and vegetation—causes influencing greatly the insect population, but the Cerceris keeps to its chosen genus, the Buprestis. For what strange reason? That is what I shall try to demonstrate.

IV

CERCERIS TUBERCULATA

WITH my mind full of the great deeds of the Buprestis hunter, I watched for an opportunity of observing in my turn the labours of the Cerceris, and I watched so closely that finally I got my chance. True, it was not the Hymenopteron celebrated by Dufour, with such sumptuous provisions that when dug up they made one think of the powder from a nugget broken by the miner's pickaxe in some gold field: it was a closely related species, a giant brigand which contents itself with more modest prey—in short, Cerceris tuberculata or C. major, the largest and strongest of the genus.

The last fortnight in September is the time when our Hymenopteron makes its burrows, and buries in the depths the prey destined for its brood. The position of the domicile, always sagaciously chosen, is governed by those mysterious laws varying with the species, but unchangeable for any one of them. The Cerceris of Léon Dufour requires a horizontal, beaten, compact soil, like that of a path, to avoid landslips and changes which would ruin its gallery with the first rain. Ours, on the

contrary, selects vertical ground. By this slight architectural modification she avoids most of the dangers which might threaten her tunnel; therefore she is not particular as to the nature of the soil, and hollows her gallery either in friable earth with a little clay, or in the crumbling soil of the Mollasse, which makes the labour of excavation much easier. The only indispensable condition seems to be that the soil should be dry, and exposed to the sun for the greater part of the day. It is therefore in the steep bank along a road, and in the sides of hollows made by rain in the sandy Mollasse, that our Hymenopteron makes its abode. Such conditions are frequent near Carpentras in what is known as the hollow way, and it is there that I have found C. tuberculata in the greatest abundance, and have collected most of the facts relating to its history.

It is not enough to choose this vertical situation; other precautions are taken to guard against the already advanced season. If some bit of hard sandstone project like a shelf, or if a hole the size of one's fist should have been hollowed naturally in the ground, it will be under this shelter or in this cavity that the gallery is made, a natural vestibule being thus added by the Cerceris to its own edifice. Although there is no kind of community among them, these insects like to associate in small parties, and I have always found their nests in groups of about ten, with orifices, though usually far apart, sometimes touching.

When the sun shines it is wonderful to see the ways of these hard-working miners. Some patiently extract bits of gravel from the bottom of a hole

with their mandibles, and push out the heavy mass; others scratch the walls of their tunnel with the sharp rakes of their tarsi, forming a heap of rubbish which they sweep out backward, and send sliding down the steep incline in long dusty streams. It was these periodical sand waves thrown out of galleries in process of construction which betrayed my first Cerceris, and led to the discovery of the nests. Others, either weary, or having completed their hard task, rested and polished their antennæ and wings under the natural caves which usually protect their dwelling, or else sat motionless at the mouth of their holes, only displaying their wide, square faces, barred with yellow and black. Others again were flying with a deep hum on the bushes near the cochineal oak, where the males, always on the watch near the burrows in process of construction, speedily join them. Couples form, often troubled by the arrival of a second male, which tries to supplant the happy possessor. The humming grows menacing, quarrels begin, and often both males roll in the dust until one acknowledges the superiority of his rival. Not far off the female waits with indifference the upshot of the struggle, accepting finally the male bestowed on her by the chances of the fight, and the pair fly out of sight to seek peace in some distant thicket. Here the part of the male ends. One half smaller than the females, they prowl about the burrows but never enter, and never take any part in the hard work of excavation, or that perhaps yet harder of provisioning the cells.

In a few days the galleries are ready, especially as after some repairs those of the preceding year

are used again. Other Cerceris, as far as I know, have no fixed home, transmitted from one generation to another. True Bohemians, they establish themselves wherever the chances of their vagabond life may lead them, so long as the soil suits them. But C. tuberculata is faithful to her penates. The projecting shelf of sandstone used by its predecessors is used again; it hollows out the same layer of sand hollowed by its forbears, and, adding its own labour to theirs, obtains deep-seated retreats sometimes only visited with difficulty. The diameter of the galleries would admit a thumb, and the insect can move about easily, even when laden with the prey which we shall see it capture. Their direction is horizontal, from four to eight inches, then makes a sudden turn downward more or less obliquely, now in one direction, now in another. Except the horizontal part, and the angle of the tunnel, the direction seems to depend on the difficulties of the ground, as is proved by the windings and changes in the farthest part of this kind of canal, which is half a yard in length. At the far end are the cells, not numerous, and provisioned with five or six dead beetles. But let us leave the details of how a Cerceris builds, and turn to more wonderful facts.

The victim chosen to feed the larvæ is a large weevil (Cleonus ophthalmicus). One sees the captor arrive, carrying the victim between its feet, body to body, head to head. It alights heavily some way from the hole to complete the journey without the aid of wings, and drags the prey laboriously with its jaws, on ground if not vertical, at least very steeply inclined, which often results in sending

CERCERIS TUBERCULATA DRAGGING WEEVIL TO ITS BURROW

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captor and captive headlong to the bottom, but the indefatigable mother finally darts into her burrow, covered with dust, but with the prey of which she has never let go. If she does not find walking with such a burden easy, it is otherwise with her flight, which is surprisingly powerful, if one considers that the strong little creature is carrying a prey nearly as large as and heavier than herself. I have had the curiosity to weigh the Cerceris and her prey separately, and the first weighed 150 milligrammes, and the second about 250, almost double.

These weights speak eloquently for the vigorous huntress, and I never wearied of watching how swiftly and easily she resumed her flight, and rose out of sight with the game between her feet when approached too closely. But she did not always fly away, and then, though it was difficult to do so, and yet avoid hurting her, I would make her drop the prey by worrying and upsetting her with a straw. Then I would take possession of the victim, and the Cerceris, thus despoiled, would hunt about, go into her hole for a moment, come out, and resume the chase. In less than ten minutes the sharp-sighted insect would find a new victim, murder it and carry it off, not seldom to my profit. Eight times running have I stolen from the same individual; eight times did the indefatigable Cerceris resume her fruitless journey. Her perseverance tired out mine, and I let her keep the ninth capture.

By this means, and by breaking open cells already filled with provisions, I got nearly a hundred weevils, and in spite of what I had a right to

expect from what Léon Dufour has told us of the habits of the Cerceris bupresticida, I could not repress my astonishment at the sight of the singular collection which I had made. His Cerceris, though it limits itself to one genus, yet takes any species within that limit, but the more exclusive C. tuberculata preys exclusively on Cleonus ophthalmicus. On looking through my booty I met with but one single exception, and that belonged to a closely allied species, C. alternans—one which I never met with again in my frequent visits to the Cerceris. Later researches furnished me with a second exception, Bothynoderes albidus, and these are all. Can a specially succulent and savoury prey explain this predilection for a single species? Do the larvæ find in this unvaried diet juices which suit them peculiarly, and which they would not find elsewhere? I do not think so, and if Léon Dufour's Cerceris hunted all the kinds of Buprestids, no doubt it was because they all have the same nutritive properties. But this must generally be the case with all the Curculionidæ; their alimentary properties must be identical, and in that case this amazing choice can only be one of size, and therefore of economy of labour and time. Our Cerceris, the giant of its race, chooses C. ophthalmicus as the largest in our district, and perhaps the commonest. But if this favourite prey fail, it must fall back upon other species, even if smaller, as is proved by the two exceptions above mentioned.

Moreover, it is by no means the only one to hunt the long-nosed class of weevils.. Many other Cerceris, according to their size, strength, and the

chances of the chase, capture Curculionidæ most various in genus, species, shape, and size. It has long been known that Cerceris arenaria feeds her young with similar food. I myself have found in its burrows Sitona lineata, S. tibialis, Cneorhinus hispidus, Brachyderes gracilis, Geonemus flabellipes, Otiorhynchus maleficus. Cerceris aurita is known to prey on Otiorhynchus raucus and Phytonomus punctatus. In the larder of Cerceris ferreri I saw Phytonomus murinus, P. punctatus, Sitona lineata, Cneorhinus hispidus, Rhynchites betuleti. This weevil, which rolls up vine leaves into the shape of cigars, is sometimes of a superb metallic blue, but more usually of a splendid golden copper. I have found as many as seven of these brilliant insects laid up in one cell, and the gorgeous colours of the little heap might almost bear comparison with the jewels buried by the huntress of the Buprestids. Other species, especially the weaker, hunt smaller game, the lesser size being compensated by numbers. Thus, Cerceris quadricincta heaps in each cell some thirty Apion gravidum, but does not disdain on occasion bigger weevils, such as Sitona lineata, Phytonomus murinus. Cerceris labiata also lays up small species. Finally, the smallest Cerceris in my part of France, C. julii, hunts the least weevils, Apion gravidum and Bruchus granarius, game proportioned to its own size. To end this list of provender, let us add that some Cerceris follow other gastronomic laws, and bring up their families on Hymenoptera. Such is C. ornata. These tastes being alien to our subject, let us pass on.

We see that out of eight species of Cerceris

which lay up Coleoptera as food, seven hunt weevils and one Buprestids. What singular reason confines the chase of these Hymenoptera within such narrow limits? What are the motives of such an exclusive selection? What internal likeness is there between the Buprestids and the weevils, outwardly quite dissimilar, that both should become food for carnivorous and nearly related larvæ? No doubt between such and such a victim there are differences as to taste and nutritive qualities which the larvæ thoroughly appreciate, but there must be a far graver reason than these gastronomic considerations to explain these strange predilections.

After all that has been so admirably said by Léon Dufour on the long and marvellous preservation of the insects destined as food for the carnivorous larvæ, it is needless to say that the weevils which I dug up, as well as those taken from between the feet of their murderer, were perfectly fresh, though permanently motionless. Freshness of colour, suppleness of the membranes and smallest articulations, normal condition of the viscera, all combine to make one doubt whether the inert body under one's eyes can really be a corpse, all the more that even under the magnifying glass it is impossible to perceive the smallest wound; and in spite of one's self one expects every moment to see the insect move and walk. Yet more, in weather so hot that insects which had died naturally would in a few hours have become dried up and crumbly, or again in damp weather which would with equal rapidity have made them decay and grow mouldy. I have kept specimens in glass tubes or cones of paper over a month with no precautions, and wonder-

CERCERIS FERRERI AND ITS PREY, THE WEEVIL;
Rhynchites betulæ on birch leaves, showing two leaves rolled up by the weevil

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ful to say, after all this length of time, the intestines were as fresh as ever, and I found dissection as easy as if the creatures were alive. No, in presence of such facts one cannot talk of an antiseptic, and believe in real death; life is still there—life latent and passive—vegetative life. It alone, struggling successfully for a time against the destructive invasion of chemical forces, can thus preserve the organism from decomposition. Life is still there, but without motion, and we have under our eyes such a marvel as chloroform or ether might produce—a marvel caused by the mysterious laws of the nervous system.

The functions of this vegetative life are slackened and troubled no doubt, but still they are feebly exercised. I have the proof of this in that action of the viscera which takes place normally and at intervals in the weevils during the first week of that deep slumber, which will never be broken, and yet which is not death. It only ceases when the intestine is empty, as is shown by autopsy. But the faint rays of life which the creature manifests do not stop there; and though sensation appears annihilated for ever, I have succeeded in reawakening some vestige of them. Having placed weevils, recently exhumed and absolutely motionless, in a bottle with sawdust moistened with benzine, I was not a little surprised to see a quarter of an hour later moving antennæ and feet. For a moment I thought I could recall them to life. Vain hope! these movements, last trace of a sensitiveness about to cease, soon stopped, and could not be excited a second time. I have repeated this experiment from

some hours to several days after the murder, and always with the same success; only movement is tardy in appearing in proportion as the date of the victim's death is distant. The movements are always from the forepart backward. First, the antennæ move, then the front tarsi tremble and share in the oscillations; next, the second pair do the same; and finally, the third. Once movement is excited, all these members oscillate without any order until all become again motionless, as they do sooner or later. Unless death has been quite recent, movement does not go beyond the tarsi, and the legs remain motionless.

Ten days after the murder I could not obtain the least sign of irritability by the proceeding described, and I had recourse to the Voltaic battery. This is more effective, and provokes muscular contractions where the vapour of benzine fails. One or two elements of Bunsen suffice, which are armed with the rheophores of slender needles. Plunging the point of the one under the furthest ring of the abdomen, and the point ot the other under the neck, you obtain each time that the current is established, not only the quivering of the tarsi, but a strong flexion of the feet, which fold themselves under the body, and relax when the current is interrupted. These movements, very energetic during the first days, gradually lose intensity, and after a certain time appear no more. On the tenth day I have still been able to obtain visible motions, but on the fifteenth the pile was unable to provoke them, notwithstanding the suppleness of the limbs and freshness of the viscera. I have submitted also

to the action of the pile Coleoptera really dead, Blaps, Saperda, Lamia, asphyxiated by benzine or sulphureous gas, and two hours later it was impossible to provoke the movements obtained so easily from weevils lying already for several days in the singular state, intermediate between life and death, into which their redoubtable enemy plunges them.

All these facts contradict the supposition of an animal completely dead, and the hypothesis of a real corpse rendered incorruptible by some antiseptic liquid. One can only explain them by admitting that the animal is struck in the principle of its movements, and that sensitiveness, suddenly benumbed, dies slowly out, while the more tenacious, vegetative functions die yet more slowly and preserve the intestines during the time necessary for the larva.

The most important detail to show was how the murder is committed. Evidently, the chief part must be played by the poisoned dart of the Cerceris. But where and how does it penetrate the body of the weevil, covered with a hard cuirass, with pieces so closely joined? Even under the magnifying glass nothing told where the sting entered. Direct examination, therefore, was required to discover the murderous ways of the Cerceris—a problem before whose difficulties Léon Dufour had already recoiled, and the solution of which seemed to me for a time impossible. I tried, however, and had the satisfaction of succeeding, though not without some groping about.

When they fly from their holes to the chase, the Cerceris go here and there, sometimes on one

side, sometimes on the other, and return from all directions, loaded with prey, so that they must seek it on all sides; but as they barely take ten minutes between going and returning, the space worked over could not be very great, especially considering the time necessary to discover the prey, to attack and render it an inert mass. I, therefore, set myself to examine all the adjacent ground with close attention, hoping to discover some Cerceris on the hunt. One afternoon devoted to this weary work convinced me of the uselessness of my researches, and of the little chance I had of surprising any of the few Cerceris, scattered here and there, and soon lost to view by their rapid flight; above all, in difficult ground, planted with olives, I gave up the attempt. But by carrying live weevils to the neighbourhood of the nests might I not tempt the Cerceris by a prey found without trouble, and so observe the drama? The notion seemed good, and the very next day I set out to find live Cleonus ophthalmicus. Vineyards, wheat-fields, and crops of lucerne, and heaps of stones did I visit and examine one and all, and after two days of close search I possessed—dare I own it?—three weevils! bare, dusty, maimed of antennæ or tarsi, shabby old creatures which, perhaps, the Cerceris would not touch! Since the day of that fevered search, when, for a weevil's sake, I bathed myself in perspiration during my wild expedition, many a year has passed, and yet, in spite of almost daily entomological researches, I am still ignorant of the life and habits of this Cleonus, which I met here and there, straying on the edge of paths. Wonderful powers of instinct!

in the same spots, and in a fraction of time, one Hymenopteron would have found hundreds of these insects which man cannot find, and found them fresh and shining, no doubt just emerged from the cocoon!

No matter; let us experiment with my wretched victim. A Cerceris has just gone into her gallery with her prey; before she comes out for a new expedition I place a weevil a few inches from her hole. The weevil moves about; when it strays too far I bring it back to its place. At last the Cerceris shows her wide face at the mouth of her hole; my heart beats fast. She walks for a few minutes near her dwelling, sees the weevil, brushes against it, turns, passes several times over its back, and flies off without even honouring my captive with a bite—my captive which cost me so much labour! I was confounded—knocked over. New attempts at other holes, new disappointments. Decidedly these dainty hunters will have none of the game which I offer them. Perhaps they find it too old, too tasteless; perhaps, in handling it, I communicated some smell to it which displeases them. Foreign contact disgusts these connoisseurs.

Should I be more fortunate if I obliged the Cerceris to defend herself? I enclosed one with a Cleonus in a bottle, irritating them by shaking it. The Hymenopteron, sensitive by nature, was more impressed than the other prisoner, with its dull, heavy organisation; she thought of escape, not attack. Their parts were exchanged; the weevil became the aggressor, sometimes seizing with the end of its trunk a foot of its mortal foe, who made

no attempt at defence, so terrified was she. I could devise nothing more; my desire to be present at the *dénoûment* had only added to former difficulties. Well, let us try again.

A luminous idea flashed upon me, bringing hope, so naturally did it touch the very heart of the question. Of course, it was the right thing and must succeed. My disdained game must be offered to the Cerceris in the heat of the chase—then, absorbed and preoccupied, she will not discover its imperfections. I have already said that on returning from the chase the Cerceris alights at the foot of the incline at some distance from the hole, whither she laboriously drags the prey. What I then had to do was to deprive her of her victim, drawing it away by one foot with pincers, and instantly throwing her the living weevil in exchange. This manœuvre succeeded perfectly. As soon as the Cerceris felt the prey slip under her body and escape her, she stamped with impatience, turned round, and perceiving the weevil which had replaced hers, flung herself upon it and clasped it in order to carry it away. But she promptly perceived that this prey was alive, and then the drama began and ended with inconceivable rapidity. The Cerceris faced her victim, seized its proboscis with her powerful jaws and grasped it vigorously, and while the weevil reared itself up, pressed her forefeet hard on its back as if to force open some ventral articulation. Then the tail of the murderess slid under the Cleonus, curved and darted its poisoned lancet swiftly two or three times at the joining of the prothorax, between the first and second pair of feet. In a twinkling all was over. Without

one convulsive movement, with no motion of the limbs such as accompany the death of an animal, the victim fell motionless for ever, as if annihilated. It was at once wonderful and terrible in its rapidity. Then the assassin turned the Weevil on its back, placing herself body to body with it, her legs on either side of it, and flew off. Three times I renewed the experiment with my three Weevils, and the same scene was always enacted.

Of course, each time I gave the Cerceris back her first prey and withdrew my Cleonus to examine it at greater leisure. This examination only confirmed my opinion of the terrible skill of the assassin. It is impossible to find the slightest trace of a wound, or the smallest flow of vital liquids from the point which was struck. But the most striking thing is the rapid, complete annihilation of all movement. Vainly did I seek even immediately after the murder for any trace of sensibility in the three Weevils done to death under my eyes—neither pinching nor pricking provoked it; to do so required the artificial means already mentioned. Thus these robust Cleonus, which, pierced alive with a pin and fixed by a collector on his fatal sheet of cork, would have struggled for days, weeks, nay, whole months, instantly lose all power of motion from the effect of a little prick which inoculates them with a minute drop of poison. Chemistry knows none so active in so small a dose; scarcely could prussic acid produce such an effect, if, indeed, it could do so at all. It is not then to toxology, but to physiology and anatomy that we must turn to find the cause of such instantaneous catalepsy; it is not so much

the great virulence of the poison injected, as the importance of the organ injured by it which we must consider in order to explain these marvels. What, then, is found at the point where the sting penetrates?

V

ONE SKILFUL TO SLAY

THE Hymenopteron has partly revealed her secret by showing us where the sting strikes. But does that explain the question? Not yet, by any means. Let us retrace our steps, forget for a moment what the insect has taught us, and consider the problem set before the Cerceris. The problem is this: to lay up in an underground cell a certain number of heads of game which may suffice to nourish the larva hatched from the egg laid upon the heap of provender.

At first sight this storing of food appears simple enough, but reflexion soon discovers graver difficulties. Our own game is brought down by a shot and killed with horrible wounds. The Hymenopteron has refinements unknown to us; she chooses to have her prey intact, with all its elegance of form and colour. No broken limbs, no gaping wounds, no hideous disembowelment. Her prey has all the freshness of the living insect; she does not destroy an atom of the fine-coloured powder which the mere contact of our fingers deflowers. If the insect were really dead, really a corpse, how difficult it would be for us to obtain such a result! Any one can slay

an insect by stamping brutally on it, but to kill it neatly leaving no sign is no easy operation, within every one's power. How many of us would be at our wits' end if we had to kill on the spot, without crushing it, a little creature so tenacious of life that even beheaded it still goes on struggling! One must have been a practical entomologist before thinking of asphyxiation, and here, again, success would be doubtful with the primitive methods of vapour of benzine or burnt sulphur. In this deleterious atmosphere the insect struggles too long, and tarnishes its brightness. One must have recourse to more heroic methods—for instance, to the terrible exhalations of prussic acid slowly disengaging themselves from strips of paper impregnated with cyanide of potassium, or better still, as being without danger to the collector, to the thunderbolt of vapour of bisulphide of carbon. It requires a real art, an art calling to its aid the redoubtable arsenal of chemistry, to kill an insect neatly; to do that is what the elegant method of the Cerceris brings about so quickly, if we admit the stupid supposition that her prey really becomes a dead body.

A dead body! But that is by no means the diet of the larvæ, little ogres greedy for fresh meat, to whom game ever so slightly tainted would inspire insurmountable disgust. They must have fresh meat with no high taste—that first sign of decay. Yet the prey cannot be laid up alive in the cell like animals destined to furnish fresh meat to the crew and passengers of a vessel. What would become of a delicate egg laid among living food? What would become of the feeble larva, a worm bruised by the slightest

thing among vigorous Coleoptera moving their long spurred legs for whole weeks? It is absolutely necessary—and here we seem caught in a blind alley—to obtain deathly immobility with the freshness of life for the interior organs. Before such an alimentary problem the best instructed man of the world would stand helpless—even the practised entomologist would own himself at a loss. The larder of the Cerceris would defy their reasoning powers.

Let us then imagine an academy of entomologists and physiologists, a congress where the question should be discussed by Flourens, Majendies, Claude Bernards. To obtain at once complete immobility and long preservation of food, the first and most natural and simple idea would be that of preserved meats. One would invoke some antiseptic liquid, as the illustrious savant of the Landes did with regard to his Buprestids, and attribute such virtue to the poisonous fluid of the Cerceris, but this strange quality has yet to be proved. Gratuitous hypothesis replacing the unknown quantity of the preserving liquid may perhaps be the final verdict of the learned assembly, as it was that of the naturalist of the Landes.

Should one insist and explain that the larvæ require not preserved food which could never have the properties of flesh still palpitating, but prey yet alive, so to say, in spite of complete absence of motion, the learned Congress, after ripe consideration, will fall back upon paralysis: "Yes, of course; the creature has to be paralysed without being killed." There is but one means of arriving at this

result, namely, to injure, cut, and destroy the nervous system of the insect in one or more skilfully chosen points.

If the question be thus left in hands unfamiliar with the secrets of a delicate anatomy it will not have advanced far. What is the arrangement of this nervous system which must be paralysed without killing the insect? First, where is it? In the head no doubt and along the back, like the brain and spinal marrow in the superior animals. "A grave mistake!" our congress would reply; the insect is so to say an animal reversed, which walks on its back—that is, it has the spinal marrow below instead of above, all along breast and stomach; therefore on the lower surface alone can the operation to paralyse the insect be performed.

This difficulty removed, a far graver one presents itself. Armed with his scalpel, the anatomist can direct its point where he will in spite of obstacles which he may have to set aside. The Hymenopteron has no choice. Its victim is a solidly cuirassed beetle, its lancet a dart, extremely delicate, which the horny mail would certainly turn aside. Only certain points are vulnerable to the frail tool, namely, the joints, protected simply by a membrane with no power of resistance. But the joints of the limbs, although vulnerable, do not in the least fulfil the necessary conditions, for through these the utmost that could be obtained is local paralysis, not one affecting the whole organism of motion. Without any prolonged struggle, without repeated operations, which, if too numerous, might endanger the victim's life, the Hymenopteron has, if possible, to abolish all

motive power at one blow. Therefore she must direct her dart at the nervous centres, the source of the power of motion whence radiate the nerves running up to the various organs of movement. Now these sources of locomotion, these nervous centres, consist of a certain number of ganglia, more numerous in the larva, less so in the perfect insect, and arranged on the median line of the under surface in a string of beads more or less distant and connected by a double ribbon of nervous tissue. In all insects which have reached the perfect state the ganglia called thoracic, *i.e.* those furnishing nerves to wings and feet and governing their movements, are three in number. Here are the points to be struck: if their action can be in any way destroyed, the possibility of movement is destroyed also.

Two ways of reaching these motive centres offer themselves to the feeble dart of the Hymenopteron; one, the joint between neck and corslet; the other the spot where the latter joins the continuation of the thorax, between the first and second pair of feet. The way through the neck does not answer; it is too far from the ganglia, which lie near the base of the feet which they animate. The blow must be dealt at the other spot, and through that only. Thus would an academy decide where Claude Bernards illuminated the question by their profound science. And it is precisely there, between the first and second pairs of feet on the median line of the under surface, that the Cerceris plunges her lancet. By what learned intelligence must she be inspired!

To choose as the spot in which to plant her sting the one vulnerable point, the point which only a

physiologist versed in the anatomy of insects could determine beforehand is by no means enough; the Hymenopteron has a far greater difficulty to overcome, and she overcomes it with a mastery which fills one with amazement. We said that the nervous centres controlling the organs of motion in an insect are three. These are more or less distant from each other, but sometimes, though rarely, near together. They possess a certain independence of action, so that an injury to one does not cause, at all events immediately, more than paralysis of members connected with it, while the other ganglia and their corresponding members are not affected by it. To reach these three sources of motion one after the other, the second farther off than the first, and the last farther still, and by a single way, between the first and second pairs of feet, seems impossible for the sting, which is too short, and besides, so difficult to aim well in such conditions. True, certain Coleoptera have the three ganglia of the thorax almost touching, and others have the two last completely united, soldered, smelted together. It is also recognised that in proportion as the different nervous centres combine and centralise, the characteristic functions of animality become more perfect, and also, alas, more vulnerable. Those Coleoptera with centres of motion so near that they touch or even gather into one mass, and so are made part of each other, would be instantly paralysed by one sting; or if several were needed, at all events the ganglia to be paralysed are all collected under the point of the dart.

Now which are the Coleoptera so specially easy

to paralyse? That is the question. The lofty science of a Claude Bernard, floating in the fundamental generalities of organisation and life, is no longer enough for us; it is unable to inform and guide us in this entomological selection. I appeal to every physiologist under whose eye these lines may fall. Without having recourse to his bookshelves, could he name the Coleoptera where such a nervous centralisation is found, and even with the help of his library, could he instantly lay his hand on the information wanted? The truth is, we are entering on the minute details of the specialist; the highway is quitted for a path known to few.

I find the necessary documents in the fine work of M. E. Blanchard (*Annales des Sciences Naturelles*, 3me série, tome v.) on the nervous system of Coleoptera. There I find that this centralisation of nerve power belongs especially to the Scarabæus, but most of these are too large; the Cerceris could neither attack nor carry them away; besides, many live in filth, where the cleanly Hymenopteron could not go to seek them. Motive centres very close together are also found among the Histers, which live on impurity, amid the smell of decay, and again that will not do; also in the Scolytus, which is too small, and finally in Buprestids and Weevils.

What unexpected light amid the pristine obscurities of the problem! Amid the immense number of the Coleoptera which the Cerceris seem able to prey upon, two groups alone, Weevils and Buprestids, fulfil the indispensable conditions. They live far from decay and dung, which perhaps cause invincible repugnance in this dainty Cerceris; they are

of most varied size, proportioned to that of their different captors, which may thus choose according to their convenience. They are far more vulnerable than all the others at the one point where the sting of the Hymenopteron can penetrate successfully, for at that point, all easily accessible to the dart, crowd the motor centres of feet and wings. At this point the three thoracic ganglia of Weevils lie very close, the hind two are contiguous. At that same spot in the Buprestids the second and third are welded in one large mass a little distance from the first. And as it is precisely Buprestids and Weevils which are hunted, to the absolute exclusion of all other game, by the eight species of Cerceris, whose food stores of Coleoptera have been ascertained, a certain internal likeness, namely, in centralisation of the nervous system must be the explanation why there are heaped in the dens of various Cerceris victims, outwardly so unlike.

In this choice, upon which even transcendent knowledge could not improve, such an assembly of difficulties is splendidly resolved, that one asks if one be not the dupe of some involuntary illusion, and if preconceived theories have not obscured the reality of facts, in short, whether the pen has not described imaginary marvels. A scientific result is only solidly established when confirmed by experiments repeated in every possible way. Now let us submit to experimental proof the physiological operation taught us by Cerceris tuberculata. If it be possible to obtain artificially what the Hymenopteron obtained by her sting, *i.e.* abolition of movement, and long preservation of the victim in a

state of perfect freshness; if it be possible to bring about this wonder with the Coleoptera hunted by the Cerceris, or with those possessing a like nervous centralisation, while one fails with those whose ganglia are far apart, one must admit, however exacting one may be in the matter of proof, that the Hymenopteron possesses in the unconscious inspirations of instinct the resources of sublime science. Let us see then what experiment shows. The manner of operation is very simple. With a needle, or, better still, with the point of a fine steel pen, we must introduce a tiny drop of some corrosive liquid into the thoracic motive centres, pricking the insect slightly at the jointing of the prothorax behind the first pair of feet. The liquid which I use is ammonia, but it is evident that any other liquid whose action is equally strong would produce the same results. The metal pen being charged with ammonia as it might be with a droplet of ink, I give the prick. The effects thus obtained differ enormously, according to whether the experiment be made upon species with thoracic ganglia near together or upon those where these same ganglia are far apart. With regard to the first category, my experiments were made on Scarabæus, S. sacer and S. longicollis; on a bronze Buprestis; and on weevils, especially that Cleonus hunted by the heroine of these observations. In the second category I have experimented on Caraboidea, Carabus, Procrustes, Chlœnius, Sphodrus, Nebria; Longicornia, Saperda, and Lamia; on Melasomes; Blaps, Scaurus, and Asida.

Among the Scarabæus class, the Buprestids, and the

Weevils, the effect is instantaneous. Every movement stops suddenly, without any convulsion, as soon as the fatal drop has touched the nerve centres. The sting of the Cerceris does not produce prompter extinction. Nothing can be more striking than this sudden immobility in a vigorous Scarabæus sacer, but the likeness between the effects produced by the dart of the Cerceris and the steel pen charged with ammonia does not stop here. Scarabæids, Buprestids, and Weevils artificially stung, in spite of their complete immobility, preserve for three weeks, one month, or even two, the perfect flexibility of every joint and the normal freshness of the interior organs. With them defecation takes place on the first days as in the normal condition, and movement can be excited by the Voltaic current. In a word, they behave exactly as do Coleoptera sacrificed by the Cerceris. There is complete identity between the state into which she plunges her victims and that produced at will by injecting ammonia into the nerve centres of the thorax. Now, as it is impossible to attribute the perfect preservation of the insect during so long a time to the drop injected, one must altogether reject the notion of an antiseptic fluid, and grant that in spite of utter immobility the creature is not really dead. A spark of life exists, keeping the organs for some time in normal freshness, but dying out by degrees and leaving them at last subject to corruption. Moreover, the ammonia in some cases produces extinction of movement in the feet only, and then the deleterious action of the fluid having doubtless not extended far enough, the antennæ preserve some mobility,

and one sees that the creature, even a month after inoculation, draws them back quickly at the least touch—an evident proof that life has not completely abandoned the inert body. This movement is not rare with Weevils wounded by the Cerceris.

Injection of ammonia always stops motion at once in Buprestids, Weevils, and Scarabæus, but it is not always possible to put the creature into the state just described. If the wound be too deep, or the little drop instilled be too strong, at the end of two or three days the victim really dies, and after two or three days there is but a decaying body. If, on the contrary, the prick be too slight, it recovers the power of motion, at least partially, after being inanimate for more or less time. The Cerceris herself may operate clumsily, just like man, for I have seen this kind of resurrection in a victim struck by the dart of a Hymenopteron. Sphex flavipennis, whose history will presently occupy us, heaps in her dens young crickets struck by her venomed lancet. From one of her holes I have taken three poor crickets whose extreme flabbiness would, in any other circumstances, have denoted death. But here, again, death was only apparent. Placed in a bottle, these crickets kept quite fresh but motionless for nearly three weeks, after which two grew mouldy, while the third came partly to life—that is to say, it regained motion of the antennæ, mouth-parts, and, which is more remarkable, of the first two pairs of feet. If even the skill of the Hymenopteron sometimes fails to benumb a victim for good and all, can one expect constant success with the rough experiments of man?

In Coleoptera of the second category—those where the ganglia of the thorax are distant one from another—the effect of ammonia is quite different. Those which show themselves least vulnerable are the Caraboidea. A puncture which would instantly have annihilated motion in the large Scarabæus sacer, in the middle size Caraboidea only causes violent, disordered convulsions. By degrees the creature quiets down, and after some hours' rest resumes its habitual movements as if nothing had happened to it. If the experiment be repeated on it twice, thrice, even four times, the results are the same, until the wound becomes too serious, and it dies outright, as is proved by the drying up and putrefaction which soon follow.

The Melasomes and the Longicorns are more sensitive to the action of ammonia. The injection of a small corrosive drop quickly renders them motionless, and after some twitching they seem dead. But the paralysis which would have persisted in Weevils, Scarabids, and Buprestids is but momentary. Before long motion reappears as energetic as before. It is only when the dose of ammonia is of a certain strength that movement does not reappear. But then the creature is really dead, and putrefaction rapidly comes on. It is then impossible to cause complete and persistent paralysis in Coleoptera with ganglia far apart by the means so efficacious in those with ganglia near together. At the utmost one can only obtain momentary paralysis, which passes quickly away. The demonstration is decisive. Cerceris which prey on Coleoptera conform in their

choice to what the most learned physiology and finest anatomy alone can teach. It would be vain to endeavour to see nothing here but chance agreement; it is not chance which explains such harmony.

VI

THE YELLOW-WINGED SPHEX

In their impenetrable coat of mail the Coleoptera offer but one vulnerable point to their dart-bearing foe. This defect in the cuirass is known to the assassin, and the poisoned sting is there inserted, striking at one blow the three centres of motion, the Weevil and Buprestid, which alone have a nervous organisation sufficiently centralised, being selected. But what happens when the insect wears no armour and is soft-skinned, so that the Hymenopteron can pierce it anywhere that the chances of the struggle may direct? Is there then a choice as to where the blow is given? Like the assassin who strikes at the heart to shorten the dangerous struggles of his victim, does the Sphex follow the tactics of the Cerceris, and strike by preference at the motor ganglia? If so, what happens when these are distant from one another, acting so independently that paralysis of one does not affect the others? These questions will be answered by the history of an insect which hunts field crickets, Sphex flavipennis.

It is towards the end of July that this Sphex

tears open the cocoon which until then has protected it, and flies away from its subterranean cradle. During the whole of August one constantly sees it seeking drops of honey on the spiny heads of Eryngium campestre, the commonest of such robust plants as brave the dog days. But this careless life is brief, for in the earliest days of September the Sphex has begun the hard existence of miner and hunter. It is usually on some small flat spot on banks along a road that the dwelling is established, only there must be two indispensable conditions—a sandy soil easy to work, and sun. Beyond this no precaution is taken to shelter the domicile against autumn rain and winter frost. A horizontal position, unsheltered, beaten by rain and wind, suit the Sphex perfectly, so long as it is exposed to the sun. But when the work is half-way through, if heavy rain should come, it is sad to see next day galleries in course of construction choked with sand and finally abandoned.

Rarely does the Sphex work in solitude; it is in small bands of ten, twenty, or more excavators that the claim selected is worked. One must have spent some days watching one of these colonies in order to form any idea of the restless activity, the feverish haste, the abrupt movements, of these hard-working miners. They rapidly attack the ground with the rakes of their forefeet, canis instar, as Linnæus says. A puppy does not show more energy in scratching up the ground in play. At the same time each labourer hums a joyous song—shrill, high-pitched, interrupted at short intervals, and modulated by vibrations of wings and thorax. One

would think they were a troop of merry comrades, stimulating one another to work by a cadenced rhythm. Meanwhile, the sand flies, falling in fine dust on their quivering wings, and the heavier gravel, pulled out bit by bit, rolls far away. If a bit resist too much, the insect goes at it with a high note, reminding one of the cry with which a woodcutter accompanies the stroke of his axe. Under the redoubled efforts of tarsi and mandibles the cavity is already sketched out, and the Sphex can already dart into it. Then comes a lively interchange of forward movements to detach material, and of backward to brush out fragments. In this hurried coming and going the Sphex does not so much walk as dart forward, as though impelled by a spring. With panting abdomen, antennæ vibrating, the whole body moved by a strong thrill, she springs forward and is out of sight. You still hear the unwearied hum underground, and one sees from time to time hind legs pushing backward a wave of sand to the mouth of the burrow. From time to time labour underground is interrupted either that the Sphex may dust herself in the sunlight, and get rid of grains of dust which insinuate themselves into delicate joints and hamper the liberty of her movements, or that she make a reconnaissance in the neighbourhood. Notwithstanding these short interruptions, in a few hours the gallery is hollowed out and the Sphex appears on her threshold, to voice her triumph, and give the last touch to her labours by effacing some inequality, or carrying away some particles of earth, the objection to which only the eye of a Sphex could perceive.

Of the many tribes of Sphegidæ visited by me, there is one of which I retain a specially lively recollection, on account of its singular installation upon the edge of a high road, where were little heaps of mud thrown up from side ditches by the cantonnier's shovel. One, well sun-dried, had a conical shape like a sugar-loaf over fifteen inches high. The situation pleased the Sphegidæ, who had established a more populous community than I have ever again met with. From base to summit the cone of dried mud was pierced with burrows, giving it the appearance of a huge sponge. In every story was feverish animation, and a busy coming and going which brought to mind the scene in some great workshop when orders are pressing. Crickets were being dragged by the antennæ up the slopes of the conical city; there was storing of provisions in the larders of the cells; dust was pouring from galleries in process of construction; at intervals the grimy faces of the miners appeared at mouths of passages—there was a constant going and coming. Now and then, in a short interval of leisure, a Sphex ascended the top of the cone, perhaps to take a general and well-satisfied view from this belvedere. What a tempting sight!—one to make me long to carry away the entire city with its inhabitants. It was useless to try; the mass was too heavy. One cannot take up a village by the roots to plant it elsewhere.

Let us look at the Sphex at work in flat ground, as is much more frequently the case. As soon as the burrow is hollowed out, the chase begins. Let us profit by the absence of the Hymenopteron

in search of game, and take a look at her dwelling. The spot chosen by a Sphex colony is generally horizontal, though the ground is not so level but that there are little mounds crowned by a tuft of grass or thrift, or inequalities consolidated by the slender roots of the vegetation which covers them. It is on the sides of such furrows that the Sphex places her den. For two or three inches in depth the gallery is horizontal, serving as an approach to the hidden shelter for the provender and the larvæ. In this vestibule the Sphex takes refuge in bad weather, rests there at night, and occasionally by day for a few instants, showing only her expressive face and impudent eyes. Beyond the vestibule an abrupt turn descends more or less obliquely to a depth of two or three inches more, ending in an oval cell rather larger in diameter, whose axis lies parallel with the horizontal gallery. The cell walls are not covered with any particular cement, but in spite of their bareness they have evidently been the object of most careful labour. The sand is heaped and levelled on the floor, on the ceiling, and sides, so as to do away with the risk of landslips, or any roughness which might injure the delicate skin of the larva. This cell communicates with the passage by a narrow entrance, just wide enough to allow the Sphex, burdened with prey, to enter. When this first cell furnished with an egg and necessary provisions, Sphex walls up the entrance, but does not yet ndon her burrow. A second cell is hollowed ide the first, and provisioned in the same manner; re is then a third made, and sometimes a fourth. ly then does the Sphex cast back into the

burrow the rubbish heaped at the entrance, completely effacing all outward trace of her work. Three cells are usually found in each burrow, rarely two, and yet more rarely four. As one learns by dissecting the insect, one may estimate the number of eggs laid at about thirty, which would make the number of burrows needed ten. Now these are hardly begun before September, and are finished before the end of the month. Consequently the Sphex cannot devote more than two or three days at most to each burrow and its stores. Evidently the active little creature has not a minute to lose, when in so short a time she has to hollow out the lair, procure a dozen crickets, sometimes brought from a distance through endless difficulties, to store them, and finally to stop up the burrow. Moreover, there are days when wind makes hunting impossible; rainy days or overcast ones suspending all work. The Sphex cannot give to her building the enduring solidity that Cerceris tuberculata gives to its deep galleries. This species transmit their solid abodes from one generation to another, each year hollowed more deeply, so that I was often bathed in perspiration when I tried to reach them, and frequently my efforts and my implements proved useless. The Sphex inherits nothing, and must herself do everything, and that rapidly. Her dwelling is but a tent, hastily erected and moved on the morrow. In compensation the larvæ, covered but by a thin layer of sand, know how to supply the shelter which their mother has not given them; they can clothe themselves with a double and triple waterproof covering, far superior to the thin cocoon of the Cerceris.

But here comes a Sphex with noisy hum, returning from the chase. She pauses on a neighbouring bush, holding in her mandibles one of the antennæ of a big cricket, weighing far more than herself. Tired out by the weight, she rests a moment, then grasps her captive between her feet, and with a supreme effort flies right across the ravine between her and her abode. She alights heavily on the flat ground where I am watching, in the very middle of a Sphex village. The rest of the journey is made on foot, the Sphex, not in the least intimidated by my presence, comes astride her victim, holding her head proudly aloft while she drags along the cricket between her feet by one of its antennæ held in her jaws. If the soil be bare there is no difficulty, but should a network of grass spread its runners across the way, it is curious to see the astonishment of the Sphex at finding her efforts baffled by this little obstacle—curious to witness her marches and countermarches and repeated attempts until the difficulty is surmounted either by the aid of her wings or a well-planned *détour*. The cricket is at last conveyed to its destination and placed so that its antennæ come exactly to the mouth of the burrow. Then the Sphex abandons it and descends in haste to the bottom of the cave. A few seconds later she puts her head out with a little cry of joy. The antennæ of the cricket are within reach; she seizes them and promptly conveys it down to her den.

I still ask myself in vain why these complicated manœuvres at the moment of conveying the cricket into the burrow. Why, instead of going down

alone and returning to resume the prey left on the threshold, does not the Sphex drag it into the gallery, as she did in the open air, since the space is wide enough, or take it with her while she enters backwards? The various predatory Hymenoptera which I have been able to observe all drag their prey at once to the bottom of their cells, holding it underneath them by their mandibles and intermediary feet. Léon Dufour's Cerceris does indeed somewhat complicate her movements, since after putting down her Buprestis for a moment at the door of her underground abode, she instantly goes backward into the gallery, seizes her victim with her mandibles and drags it down; but that is very unlike the tactics adopted in a like case by the Sphex. Why this domiciliary visit, which invariably precedes the introduction of the prey? May it not be that before descending hampered by a load, the Sphex thinks it prudent to give a look round the bottom of her dwelling to make sure that all is in order and to drive out, if necessary, some impertinent parasite which may have slipped in during her absence? Several Diptera, predatory flies, especially Tachinidæ, watch at the doors of all the hunting Hymenoptera, spying out the favourable moment to lay their eggs on other people's game, but none penetrate into the dwelling, nor venture into the dark passages, where, if by ill-luck the owner caught them, they might have to pay dearly for their audacity. The Sphex, like others, pays her tribute to the predatory Tachinidæ, but they never enter her burrow to commit their misdeeds. Besides, have they not all the time they need to lay their eggs on the cricket?

If they look sharp, they may very well profit by the Sphex's momentary absence from her victim to confide their posterity to it. What yet greater danger menaces the Sphex which renders this preliminary descent to the bottom of the burrow such an imperious necessity?

The one observed fact which can throw any light on the problem is this. Amid a colony of Sphegidæ in full activity, whence all other Hymenoptera are habitually excluded, I one day surprised a sportsman of a different kind, Tachytes nigra, carrying one by one, without any haste and with the greatest composure, amid the crowd where he was but an intruder, grains of sand, little bits of dry stalk, and other small materials, to stop up a burrow of the same shape and size as the neighbouring ones of the Sphegidæ. This labour was pursued too conscientiously to admit of any doubt as to the presence of the worker's egg in the underground dwelling. A Sphex with anxious movements, apparently the legitimate owner of the burrow, never failed each time that the Tachytes entered the gallery to dart in pursuit, but emerged swiftly, as if frightened, followed by the other, who continued her task unmoved. I visited this burrow, the evident cause of strife between them, and found a cell provisioned with four crickets. Suspicion almost gave place to certainty, for this allowance far exceeded the needs of a Tachytes' larva, which is at least one-half smaller than the Sphex. The calm insect whose care to stop up the burrow at first suggested that it was the owner was really a usurper. How comes it that the Sphex, larger and

more robust than her adversary, allows herself to be robbed with impunity, limiting herself to a fruitless pursuit, and flying like a coward when the intruder, who seems not even to perceive her, turns round to come out of the burrow? Is it with insects as with men, the first quality needed for success is audacity—audacity—audacity? Certainly the usurper had no lack of it. I can still see that Tachytes, imperturbably calm, going and coming before the meek Sphex, which stamped with impatience, but did not venture to fall upon the thief.

Let us add that in other circumstances I have repeatedly found this Hymenopteron, I suppose to be a parasite—this Tachytes nigra, dragging a cricket by one of its antennæ. Was it a prey lawfully acquired? I would fain think so, but the indecision of the insect which strayed about the ruts in the paths as if seeking a convenient burrow always left me suspicious. I have never been present when it burrowed, if indeed it ever does undertake that labour, and what is more, I have seen it abandon its game to decay, perhaps not knowing what to do with it for want of a hole where to put it. Such wastefulness seems to indicate goods ill-gotten, and I ask myself if the cricket were not stolen when the Sphex left it on her threshold? I also suspect Tachytes obsoleta, banded with white round the abdomen like Sphex albisecta, which nourishes its larvæ with crickets such as are hunted by the latter. I have never seen it digging galleries, but I have caught it dragging crickets that the Sphex would not have disdained. This similarity of food in species of different genera makes me doubtful whether the

booty were lawfully come by. Let me add, however, to atone in some measure for the injury which my suspicions may do to the character of the genus, that I have seen the perfectly lawful capture of a little cricket yet wingless by Tachytes tarsina, and have also seen it hollow cells and store them with prey bravely acquired. Thus I have only suspicions to offer as to why the Sphex persists in descending to the bottom of her hole before carrying in prey. Is there some other end besides that of dislodging a parasite which may have got in during the owner's absence? I despair of finding out; who can interpret the thousand manœuvres of instinct? Poor human reason which cannot even explain the wisdom of a Sphex!

At all events, it is proved that these manœuvres are singularly invariable, *àpropos* of which I will mention an experiment which greatly interested me. At the moment when the Sphex makes her domiciliary visit, I take the cricket and put it some way off. The Sphex comes up, utters her usual cry, looks round with astonishment, and seeing the game too far off, comes out to seize and put it in the right position. Then she goes down again without the cricket. Same manœuvre on my part, same disappointment when she reappears. Again the prey is brought to the mouth of the hole, and again the Sphex goes down alone, and so on as long as my patience holds out. Forty times on end have I tried the experiment on the same individual; her persistence vanquished mine, and her tactics never varied.

Having proved the inflexible pertinacity of all

the Sphegidæ in one colony on whom I cared to experiment, I could not but perplex myself over it. "Does then the insect obey a fixed tendency which circumstances cannot modify?" I asked myself. "Are its actions all done by rule, and is it unable to acquire the least experience from its own proceedings?" Later observations modified this too absolute judgment.

The following year, at the proper time, I visited the same spot. The new generation had inherited for their burrows the place chosen by the preceding ones; it had also faithfully inherited their tactics, for the cricket experiment gave the same results. Such as were the Sphegidæ of the past year such are those of the present one, equally persistent in a fruitless attempt. My error grew confirmed until good luck brought me to another colony in a different place. I renewed my experiments. After two or three trials with the old, well-known result, the Sphex got astride of the cricket, seized its antennæ with her mandibles, and dragged it at once into the burrow. Who looked a fool then? The experimenter baffled by the clever Hymenopteron. At the other holes her neighbours, some sooner, some later, found me out, and went down with their prey instead of persisting in leaving it on the threshold to seize it later. What is the meaning of this? This colony, descended from another stock, for sons return to the spot selected by their forefathers, is cleverer than the one observed last year. Craft is inherited; there are sharper-witted tribes and duller ones, apparently according to the faculties of their forefathers. With Sphegidæ, as with us, the kind

of intellect changes with the province. Next day I tried the cricket experiment in another locality, and it invariably succeeded. I had come upon a dense-minded tribe, a true colony of Bœotians, as in my earlier observations.

VII

THREE STROKES OF A DAGGER

THERE can be no doubt that the Sphex uses her greatest skill when immolating a cricket; it is therefore very important to explain the method by which the victim is sacrificed. Taught by my numerous attempts to observe the war tactics of the Cerceris, I immediately used on the Sphex the plan already successful with the former, *i.e.* taking away the prey and replacing it by a living specimen. This exchange is all the easier because, as we have seen, the Sphex leaves her victim while she goes down her burrow, and the audacious tameness, which actually allows her to take from your finger-tips, or even off your hand, the cricket stolen from her and now offered, conduces most happily to a successful result of the experiment by allowing the details of the drama to be closely observed.

It is easy enough to find living crickets; one has only to lift the first stone, and you find them, crouched and sheltering from the sun. These are the young ones of the current year, with only rudimentary wings, and which, not having the industry of the perfect insect, do not yet know how to dig deep

retreats where they would be beyond the investigations of the Sphex. In a few moments I find as many crickets as I could wish, and all my preparations are made. I ascend to the top of my observatory, establish myself on the flat ground in the midst of the Sphex colony and wait.

A huntress comes, conveys her cricket to the mouth of her hole and goes down alone. The cricket is speedily replaced by one of mine, but placed at some distance from the hole. The Sphex returns, looks round, and hurries to seize her too distant prey. I am all attention. Nothing on earth would induce me to give up my part in the drama which I am about to witness. The frightened cricket springs away. The Sphex follows closely, reaches it, darts upon it. Then there is a struggle in the dust when sometimes conqueror, sometimes conquered is uppermost or undermost. Success, equal for a moment, finally crowns the aggressor. In spite of vigorous kicks, in spite of bites from its pincer-like jaws, the cricket is felled and stretched on its back.

The murderess soon makes her arrangements. She places herself body to body with her adversary, but in a reverse position, seizes one of the bands at the end of the cricket's abdomen and masters with her forefeet the convulsive efforts of its great hind-thighs. At the same moment her intermediate feet squeeze the panting sides of the vanquished cricket, and her hind ones press like two levers on its face, causing the articulation of the neck to gape open. The Sphex then curves her abdomen vertically, so as to offer a convex surface impossible for the

mandibles of the cricket to seize, and one beholds, not without emotion, the poisoned lancet plunge once into the victim's neck, next into the jointing of the two front segments of the thorax, and then again towards the abdomen. In less time than it takes to tell, the murder is committed, and the Sphex, after setting her disordered toilette to rights, prepares to carry off her victim, its limbs still quivering in the death-throes. Let us reflect a moment on the admirable tactics of which I have given a faint sketch. The Cerceris attacks a passive adversary, incapable of flight, whose sole chance of safety is found in a solid cuirass whose weak points the murderers know. But here what a difference! The prey is armed with redoubtable mandibles, capable of disembowelling the aggressor if they can seize her, and a pair of strong feet, actual clubs, furnished with a double row of sharp spines, which can be used alternatively to enable the cricket to bound far away from an enemy or to overturn one by brutal kicks. Accordingly, note what precautions on the part of the Sphex before using her dart. The victim, lying on its back, cannot escape by using its hind levers, for want of anything to spring from, as of course it would were it attacked in its normal position, as are the big Weevils by Cerceris tuberculata. Its spiny legs, mastered by the fore-feet of the Sphex, cannot be used as offensive weapons, and its mandibles, held at a distance by the hind-feet of the Hymenopteron, open threateningly but can seize nothing. But it is not enough for the Sphex to render it impossible for her victim to hurt her: she must hold it so firmly garrotted that no

movement can turn the sting from the points where the drop of poison must be instilled, and probably it is in order to hinder any motion of the abdomen that one of the end segments is grasped. If a fertile imagination had had free play to invent a plan of attack it could not have devised anything better, and it is questionable whether the athletes of the classic palestra when grappling an adversary would have assumed attitudes more scientifically calculated.

I have just said that the dart is plunged several times into the victim's body, once under the neck, then behind the prothorax, lastly near the top of the abdomen. It is in this triple blow that the infallibility, the infused science of instinct, appear in all their magnificence. First let us recall the chief conclusions to which the preceding study of the Cerceris have led us. The victims of Hymenoptera whose larva live on prey are not corpses, in spite of entire immobility. There is merely total or partial paralysis, and more or less annihilation of animal life, but vegetative life—that of the nutritive organs—lasts a long while yet, and preserves from decomposition the prey which the larvæ are not to devour for a considerable time. To produce this paralysis the predatory Hymenoptera use just those methods which the advanced science of our day might suggest to the experimental physiologist—namely, wounding, by means of a poisoned dart, those nervous centres which animate the organs of locomotion. We know too that the various centres or ganglia of the nervous chain in articulate animals act to a certain degree independently, so that injury to one only causes, at all events immediately, paralysis of the corresponding

segment, and this in proportion as the ganglia are more widely separated and distant from each other. If, on the contrary, they are soldered together, injury to the common centre causes paralysis of all the segments where its ramifications spread. This is the case with Buprestids and Weevils, which the Cerceris paralyses by a single sting, directed at the common mass of the nerve centres in the thorax. But open a cricket, and what do we find to animate the three pairs of feet? We find what the Sphex knew long before the anatomist, three nerve centres far apart. Thence the fine logic of the three stabs. Proud science! humble thyself.

Crickets sacrificed by Sphex flavipennis are no more dead, in spite of all appearances, than are Weevils struck by a Cerceris. The flexibility of the integuments displays the slightest internal movement, and thus makes useless the artificial means used by me to show some remains of life in the Cleonus of Cerceris tuberculata. If one closely observes a cricket stretched on its back a week or even a fortnight or more after the murder, one sees the abdomen heave strongly at long intervals. Very often one can notice a quiver of the palpi and marked movements in the antennæ and the bands of the abdomen, which separate and then come suddenly together. By putting such crickets into glass tubes I have kept them perfectly fresh for six weeks. Consequently, the Sphex larvæ, which live less than a fortnight before enclosing themselves in their cocoons, are sure of fresh food as long as they care to feast.

The chase is over; the three or four crickets needed to store a cell are heaped methodically on their backs, their heads at the far end, their feet

toward the entrance. An egg is laid on each. Then the burrow has to be closed. The sand from the excavation lying heaped before the cell door is promptly swept out backward into the passage. From time to time fair-sized bits of gravel are chosen singly, the Sphex scratching in the fragments with her forefeet, and carrying them in her jaws to consolidate the pulverised mass. If none suitable are at hand, she goes to look for them in the neighbourhood, apparently choosing with such scrupulous care as a mason would show in selecting the best stones for a building. Vegetable remains and tiny bits of dead leaf are also employed. In a moment every outward sign of the subterranean dwelling is gone, and if one has not been careful to mark its position, it is impossible for the most attentive eye to find it again. This done, a new burrow is made, provisioned and walled up as soon as the Sphex has eggs to house. Having finished laying, she returns to a careless and vagabond life until the first cold weather ends her well-filled existence.

The Sphex's task is accomplished. I will finish mine by an examination of her weapon. The organ destined for the elaboration of her poison is composed of two elegantly branched tubes communicating separately with a common reservoir or pear-shaped vial, whence proceeds a slender channel leading to the axis of the sting and conducting to its end the little poisoned drop. The dart is extremely small, and not such as one would expect from the size of the Sphex, especially from the effect which her sting produces on crickets. The point is quite smooth, without the barbs found in the sting of the hive bee.

The reason of this is evident. The bee uses her sting to avenge an injury only at the cost of life, the barbs preventing its withdrawal from the wound, and thus causing mortal ruptures in the viscera at the end of the abdomen. What could the Sphex have done with a weapon which would have been fatal the first time it was used? Even supposing that the barbed dart could have been withdrawn, I doubt if any Hymenopteron using its weapon, especially to wound game destined for its progeny, would be provided with one. For here the dart is not a fine gentleman's weapon, unsheathed for vengeance, which is said to be the pleasure of the gods, but a very costly one, since the vindictive bee sometimes pays for it with life. It is a worker's tool, on which depends the future of the larvæ, thus it should be one easily used in a struggle with captured prey, plunging into and coming out of the flesh without any delay—a condition much better fulfilled by a smooth blade than by a barbed one.

I wished to ascertain at my own expense if the Sphex's sting be very painful—that sting which knocks over robust victims with frightful rapidity. Well, I own with great admiration that it is slight and cannot be at all compared as to pain with those of the bee and the irascible wasp. It hurts so little that, instead of using pincers, I never hesitated to catch with my fingers any Sphegidæ which I wanted for my researches. I may say the same of the various Cerceris, Philanthides, Palares, and even of the huge Scoliides, whose very look is terrifying, and in general of all predatory Hymenoptera which I have been able to observe. I except, however, those that hunt spiders,

the Pompili, and even their sting is far less severe than that of a bee.

One last remark. We know how furiously Hymenoptera armed with a sting used only for defence rush at the bold man who disturbs their nest, and punish his temerity. Those on the contrary whose sting is used only for hunting are very pacific, as if they guessed how important for their family is the little poison drop in their vase. That droplet is the safeguard of their race—I might really say their means of subsistence; therefore they use it economically, in the serious business of the chase, with no parade of vengeful courage. I was not once punished by a sting when I established myself amid colonies of our various predatory Hymenoptera, whose nests I overturned, carrying off larvæ and provisions. To induce the creature to use its weapon, one must lay hold of it, and even then the skin is not always pierced, unless one puts within reach a part more delicate than the fingers, such as the wrist.

VIII

LARVA AND NYMPH

THE egg of Sphex flavipennis is white, elongated, and cylindrical, slightly curved, and measuring three to four millimetres in length. Instead of being laid fortuitously on any part of the victim, it is invariably placed on one spot, across the cricket's breast—a little on one side, between the first and second pairs of feet. The eggs of the white bordered, and of the Languedocian Sphex occupy a like position—the first on the breast of a cricket, the second on that of an ephippiger. This chosen spot must possess some highly important peculiarity for the security of the young larva, as I have never known it vary.

Hatching takes place at the end of two or three days. A most delicate covering splits, and one sees a feeble maggot, transparent as crystal, somewhat attenuated and even compressed in front, slightly swelled out behind, and adorned on either side by a narrow white band formed by the chief trachea. The feeble creature occupies the same position as the egg; its head is, as it were, engrafted on the same spot where the front end of the egg was fixed, and the remainder of its body rests on the victim without

adhering to it. Its transparency allows us readily to perceive rapid fluctuations within its body, undulations following one another with mathematical regularity, and which, beginning in the middle of the body, are impelled, some forward and some backward. These are due to the digestive canal, which imbibes long draughts of the juices drawn from the sides of the victim.

Let us pause a moment before a spectacle so calculated to arrest attention. The prey is laid on its back, motionless. In the cell of Sphex flavipennis it is a cricket, or three or four, piled up; in that of the Languedocian Sphex there is a single victim, but proportionately large, a plump-bodied ephippiger. The grub is a lost grub if torn from the spot whence it draws nourishment. Should it fall, all is over, for weak as it is, and without means of locomotion, how would it again find the spot where it should quench its thirst? The merest trifle would enable the victim to get rid of the animalcule gnawing at its entrails, yet the gigantic prey gives itself up without the least sign of protestation. I am well aware that it is paralysed, and has lost the use of its feet from the sting of its assassin, but at this early stage it preserves more or less power of movement and sensation in parts unaffected by the dart. The abdomen palpitates, the mandibles open and shut, the abdominal styles and the antennæ oscillate. What would happen if the grub fixed on one of the spots yet sensitive near the mandibles, or even on the stomach, which, being tenderer and more succulent, would naturally suggest itself as fittest for the first mouthfuls of the feeble grub? Bitten on the quick parts,

cicada, cricket, and ephippiger would display at least some shuddering of the skin, which would detach and throw off the minute larva, for which probably all would be over, since it would risk falling into the formidable, pincer-like jaws.

But there is a part of the body where no such peril is to be feared—the thorax wounded by the sting. There and there only can the experimenter on a recent victim dig down the point of a needle—nay, pierce through and through without evoking any sign of pain. And there the egg is invariably laid—there the young larva always attacks its prey. Gnawed where pain is no longer felt, the cricket does not stir. Later, when the wound has reached a sensitive spot, it will move of course as much as it can; but then it is too late—its torpor will be too deep, and besides, its enemy will have gained strength. That is why the egg is always laid on the same spot, near the wounds caused by the sting on the thorax, not in the middle, where the skin might be too thick for the new-born grub, but on one side—toward the junction of the feet, where the skin is much thinner. What a judicious choice! what reasoning on the part of the mother when, underground, in complete darkness, she perceives and utilises the one suitable spot for her egg!

I have brought up Sphex larvæ by giving them successively crickets taken from cells, and have thus been able, day by day, to follow the rapid progress of my nurslings. The first cricket—that on which the egg is laid—is attacked, as I have already said, toward the point where the dart first struck—between the first and second pairs of legs. At the end of a

few days the young larva has hollowed a hole big enough for half its body in the victim's breast. One may then sometimes see the cricket, bitten to the quick, vainly move its antennæ and abdominal styles, open and close its empty jaws, and even move a foot, but the larva is safe and searches its vitals with impunity. What an awful nightmare for the paralysed cricket! This first ration is consumed in six or seven days; nothing is left but the outer integument, whose every portion remains in place. The larva, whose length is then twelve millimetres, comes out of the body of the cricket through the hole it had made in the thorax. During this operation it moults, and the skin remains caught in the opening. It rests, and then begins on a second ration. Being stronger it has nothing to fear from the feeble movements of the cricket, whose daily increasing torpor has extinguished the last shred of resistance, more than a week having passed since it was wounded; so it is attacked with no precautions, and usually at the stomach, where the juices are richest. Soon comes the turn of the third cricket, then that of the fourth, which is consumed in ten hours. Of these three victims there remains only the horny integument, whose various portions are dismembered one by one and carefully emptied. If a fifth ration be offered, the larva disdains or hardly touches it, not from moderation, but from an imperious necessity.

It should be observed that up to now the larva has ejected no excrement, and that its intestine, in which four crickets have been engulfed, is distended to bursting. Thus, a new ration cannot tempt its

gluttony, and henceforward it only thinks about making a silken dwelling. Its repast has lasted from ten to twelve days without a pause. Its length now measures from twenty-five to thirty millimetres, and its greatest width from five to six. Its usual shape, somewhat enlarged behind and narrowed in front, agrees with that general in larvæ of Hymenoptera. It has fourteen segments, including the head, which is very small, with weak mandibles seemingly incapable of the part just played by them. Of these fourteen segments the intermediary ones are provided with stigmata. Its livery is yellowish-white, with countless chalky white dots.

We saw that the larva began on the stomach of the second cricket, this being the most juicy and fattest part. Like a child who first licks off the jam on his bread, and then bites the slice with contemptuous tooth, it goes straight to what is best, the abdominal intestines, leaving the flesh, which must be extracted from its horny sheath, until it can be digested deliberately. But when first hatched it is not thus dainty: it must take the bread first and the jam later, and it has no choice but to bite its first mouthful from the middle of the victim's chest, exactly where its mother placed the egg. It is rather tougher, but the spot is a secure one, on account of the deep inertia into which three stabs have thrown the thorax. Elsewhere, there would be, generally, if not always, spasmodic convulsions which would detach the feeble thing and expose it to terrible risks amid a heap of victims whose hind legs, toothed like a saw, might occasionally kick, and whose jaws could still grip. Thus it is motives of

security, and not the habits of the grub, which determine the mother where to place its egg.

A suspicion suggests itself to me as to this. The first cricket, the ration on which the egg is laid, exposes the grub to more risks than do the others. First, the larva is still a weakly creature; next, the victim was only recently stung, and therefore in the likeliest state for displaying some remains of life. This first cricket has to be as thoroughly paralysed as possible, and therefore it is stabbed three times. But the others, whose torpor deepens as time passes,—the others which the larvæ only attack when grown strong,—have they to be treated as carefully? Might not a single stab, or two, suffice to bring on a gradual paralysis while the grub devours its first allowance? The poison is too precious to be squandered; it is powder and shot for the Sphex, only to be used economically. At all events, if at one time I have been able to see a victim stabbed thrice, at another I have only seen two wounds given. It is true that the quivering point of the Sphex's abdomen seemed seeking a favourable spot for a third wound; but if really given, it escaped my observation. I incline to believe that the victim destined to be eaten first always is stabbed three times, but that economy causes the others only to be struck twice. The study of the caterpillar-hunting Ammophila will later confirm this suspicion.

The last cricket being finished, the larva sets to work to spin a cocoon. In less than forty-eight hours the work is completed, and henceforward the skilful worker may yield within an impenetrable shelter to the overpowering lethargy which is steal-

ing over it—a state of being which is neither sleeping nor waking, death nor life, whence it will issue transfigured ten months later. Few cocoons are so complex as is this one. Besides a coarse outer network, there are three distinct layers, forming three cocoons, one within another. Let us examine in detail these various courses of the silken edifice. First comes an open network, coarse and cobwebby, on which the larva places itself and hangs as in a hammock to work more easily at the cocoon properly so called. This incomplete net, hastily spun to serve as a scaffolding, is made with threads carelessly placed and holding grains of sand, bits of earth, and remains from the larva's banquet—cricket's thighs, still banded with red, feet, and skull. The next covering, which is the first of the real cocoon, is a felted wrapper, light red, very fine, very supple, and somewhat crumpled. A few threads cast here and there connect it with the preceding scaffolding and the following covering. It forms a cylindrical purse, with no opening and too large for what it contains, thus causing the surface to wrinkle. Then comes an elastic case, markedly smaller than the purse which contains it, almost cylindrical, and rounded at the upper end, toward which is turned the head of the larva, while at the lower it makes a blunt cone. Its colour is light red, except towards the lower end, where the shade is darker. It is fairly firm, though it yields to a moderate pressure, except in the conical part, which resists and seems to contain a hard substance. On opening this sheath it is seen to be formed of two layers closely pressed together, but easily separable. The outer is a silken felt

precisely like that of the preceding purse, the inner one, the third of the cocoon, is a kind of lacquer—a brilliant violet-brown varnish, fragile, very soft to the touch, and of quite a different nature to the rest of the cocoon. The microscope shows that instead of being a felt of silky filaments like the other coverings, it is a homogeneous covering of a peculiar varnish, whose origin is, as we shall see, sufficiently strange. As for the resistance of the conical end of the cocoon, one finds it caused by a load of friable matter, dark violet, and shining with numerous black particles. This load is the dry mass of excrement, ejected once for all by the larva, inside its cocoon, and to it is due the darker colour of the conical end. The average length of this complex dwelling is twenty-seven millimetres, and its greatest width nine.

Let us return to the purple varnish which covers the interior of the cocoon. At first, I thought it should be attributed to the silk glands, which, after serving to spin the double wrapper of silk and the scaffolding, must finally have secreted it. To convince myself, I opened larvæ which had just completed their task of weaving, and had not yet begun to lay on the lacquer. At that period I found no trace of violet fluid in their glands. It is only seen in the digestive canal, which is swelled with a purple pulp, and later in the stercorous load sent down to the lower end of the cocoon. Elsewhere all is white, or faintly tinged with yellow. I am far from suggesting that the larva plasters its cocoon with excrement, yet I am convinced that this wash is produced by the digestive organs, and I

suspect—though I cannot positively assert it, having several times missed the moment to ascertain it—that the larva disgorges and applies with its mouth the quintessence of the purple pulp in its stomach to make the wash of lacquer. Only after this last piece of work would it eject the remains of digestion in a single mass, and thus is explained the disgusting necessity of storing the excrement within the larva's habitation.

At all events the usefulness of this layer is clear; its absolute impermeability protects the larva from the damp which would certainly penetrate the poor shelter hollowed for it by its mother. Recollect that it is buried but a few inches deep in sandy, open ground. To judge how far cocoons thus varnished are capable of resisting damp, I have plunged them in water for several days, yet never found any trace of moisture within them. Let us compare the Sphex cocoon, with manifold coverings to protect the larva in a burrow itself unprotected, with that of Cerceris tuberculata, sheltered by a layer of sandstone, more than half a yard down in the ground. This cocoon has the form of a very long pear, with the small end cut off. It is composed of a single silken wrap, so fine that the larva is seen through it. In my many entomological researches I have always found the labour of larva and mother supplement each other. In a deep well-sheltered dwelling the cocoon is of light materials; for a surface abode, exposed to wind and weather, it is strongly constructed.

Nine months pass, during which a work is done which is quite hidden. I pass over this period,

occupied by the unknown mystery of transformation, and to come to the nymph, go from the end of September to the first days of the following July. The larva has thrown aside its faded vestment, and the chrysalis, a transitory organisation, or rather, a perfect insect in swaddling bands, awaits motionless the awakening which is still a month off. Feet, antennæ, the visible portions of the mouth, and the undeveloped wings, look like clearest crystal, and are regularly spread out under the thorax and abdomen. The rest of the body is of an opaque white, slightly tinged with yellow; the four intermediary segments of the abdomen show on either side a narrow, blunt prolongation; the last segment has above a blade-like termination, shaped like the section of a circle, furnished below with two conical protuberances, side by side, thus making in all eleven appendages starring the contour of the abdomen. Such is the delicate creature which, to become a Sphex, must assume a particoloured livery of black and red, and throw off the fine skin which swaddles it so closely.

I have been curious to follow day by day the progress and coloration of the chrysalid, and to experiment whether sunlight—that rich palette whence Nature draws her colours—could influence their progress. With this aim I have taken chrysalids out of their cocoon and kept them in glass tubes, where some, in complete darkness, realised natural conditions, while others, hung up against a white wall, were all day long in a strong light. These diametrically opposed conditions did not affect the colouring, or if there were some slight difference, it was to the disadvantage of those exposed to light.

Quite unlike to what occurs with plants, light does not influence insect-colouring, nor even quicken it. It must be so, since in the species most gifted with splendid colour—Buprestids and Carabids for instance—the wonderful hues that would seem stolen from a sunbeam are really elaborated in darkness, deep in the ground, or in the decayed trunk of some aged tree.

The first indication of colour is in the eyes, whose horny facets pass successively from white to tawny, then to a slaty hue, and lastly to black. The simple ones at the top of the forehead share in their turn in this coloration before the rest of the body has at all lost its whitish tint. It should be noted that this precocity in the most delicate of organs, the eye, is general in animals. Later a smoky line appears in the furrow separating the mesothorax from the metathorax, and four-and-twenty hours later the whole back of the mesothorax is black. At the same time the division of the prothorax grows shaded, a black dot appears in the central and upper part of the metathorax, and the mandibles are covered with a rusty tint. Gradually a deeper and deeper shade spreads over the last segments of the thorax, and finally reaches the head and sides. One day suffices to turn the smoky tint of the head and the furthest segments of the thorax into deep black. Then the abdomen shares in the rapidly increasing coloration. The edge of the anterior segments is tinted with daffodil, while the posterior segments acquire a band of ashy black. Then the antennæ and feet take a darker and darker tint, till they become black, all the base of the abdomen turns

orange-red, and the tip black. The livery would then be complete, but that the tarsi and mouth-pieces are transparent red and the stumps of wings ashy black. Four-and-twenty hours later the chrysalis will burst its bonds. It only takes six or seven days to acquire its permanent tints; the eyes have done so a fortnight before the rest of the body. From this sketch the law of chromatic evolution is easily apprehended. We see that, omitting the eyes and ocelli, whose early perfection recalls what takes place in the higher animals, the starting-point of coloration is a central one, the mesothorax, whence it invades progressively by centrifugal progression—first the rest of the thorax, then the head and abdomen, and finally the various appendages, antennæ, and feet. The tarsi and mouthpieces take colour later still, and the wings only on coming out of their cases.

Now we have the Sphex in full costume, but she still has to free herself from the chrysalis case. This is a very fine wrap, enfolding every smallest detail of structure, and hardly veiling the shape and colours of the perfect insect. As prelude to the last act of metamorphosis, the Sphex, rousing suddenly from her torpor, begins to shake herself violently, as if to call life into her long-benumbed limbs. The abdomen is alternately lengthened and contracted, the feet are suddenly spread, then bent, then spread again, and their various joints are stiffened with effort. The creature, curved backwards on its head and the point of the abdomen, with ventral surface upward, distends by vigorous shakes the jointing of its neck and of the petiole

attaching the abdomen to the thorax. At last its efforts are crowned with success, and after half an hour of these rough gymnastics the sheath, pulled in every direction, ruptures at the neck, at the insertion of the feet and petiole, and, in short, wherever the body has been movable enough to allow of sufficiently violent displacement.

All these tears leave several irregular strips, the chief of which envelops the abdomen and comes up the back of the thorax. To it belong the wing sheaths. A second strip covers the head. Lastly, each foot has its own sheath, more or less dilapidated toward the base. The biggest, which forms the chief part of the whole covering, is got off by alternate dilatations and contractions of the abdomen, which gradually push it back into a little ball connected for some time with the animal by tracheal filaments. Then the Sphex again becomes motionless, and the operation is over, though head, antennæ, and feet are still more or less covered. It is clear that the feet cannot be freed in one piece on account of the roughnesses and thorns with which they are armed. These rags of skin dry up and are got rid of later by rubbing the feet together, and by brushing, smoothing, and combing the whole body with the tarsi when the Sphex has acquired full vigour.

The way in which the wings come out of their sheaths is the most remarkable feature in this casting of the skin. In their undeveloped state they are folded lengthways and much contracted. A little while before they acquire their normal appearance one can easily draw them out of their sheaths;

but then they do not expand, remaining always crumpled, while, when the large piece of which the sheaths are a part is pushed back by the movements of the abdomen, they may be seen issuing gradually from the sheaths, and immediately they gain freedom, assuming dimensions out of all proportion to the narrow prison from which they emerge. They are then the seat of an abundant influx of vital juices which swell and spread them out, and the turgescence thus induced must be the chief cause of their coming out of their sheaths. When freshly expanded the wings are heavy, full of moisture, and of a very light straw colour. If the influx should take place in an irregular manner, the point of the wing is seen to be weighed down by a yellow droplet contained between its under and upper surface.

After denuding itself of the abdominal sheath, which draws away with it the wing-cases, the Sphex again is motionless for about three days. During this interval the wings assume their normal colouring, the tarsi take colour also, and the mouth-parts, at first spread out, assume their normal position. After twenty-four days as a nymph the insect attains its perfect state, tears its imprisoning cocoon, opens a way through the sand, and appears one fine morning in the light as yet unknown to it. Bathed in sunshine, it brushes wings and antennæ, passes its feet again and again over its abdomen, washes its eyes with its forefeet moistened with saliva, like a cat, and, its toilette made, flies joyfully away. Two months of life are before it.

Beauteous Sphegidæ, hatched under my eyes

and brought up by my hand, ration by ration, on a bed of sand, at the bottom of an old feather box,—you whose transformations I have followed step by step, waking up with a start at night for fear of missing the moment when the nymph breaks through her swaddling bands and the wings issue from their cases. You have taught me so many things, learning nothing yourselves, knowing without teachers all that you need to know. Oh, my beautiful Sphegidæ! fly away without fear of my tubes, my phials, and all my boxes and cages, and all my prisons for you; fly through the warm sunshine, beloved by the cicadas! Go, and beware of the Praying Mantis, who meditates your destruction on the purple thistles; beware of the lizard watching for you on the sunny slopes. Depart in peace, hollow out your burrows, stab your crickets scientifically, and continue your race, so as to afford to others what you have afforded to me—some of the few moments of happiness in my life.

IX

ADVANCED THEORIES

THERE are many species of Sphex, but for the most part strangers to our country. As far as I know, the French fauna contains but three—all lovers of the hot sun in the olive region—namely, Sphex flavipennis, S. albisecta, and S. occitanica. It is not without keen interest that an observer notices in all three of these predatory insects a choice of provender in conformity with the strict laws of entomological classification. To nourish their larvæ each confines itself to Orthoptera. The first hunts grasshoppers, the second crickets, and the third ephippigers.

These prey are so different outwardly that to associate them and seize their analogies, either the practised eye of the entomologist, or the not less expert one of the Sphex is needed. Compare the grasshopper with the cricket: the former has a round, stumpy head; it is short and thickset, quite black, with red stripes on its hind thighs; the latter is grayish and slim, with a small conical head, springing suddenly by unbending its long hind legs, and carrying on this spring with fanlike wings. Now

compare both with the ephippiger, who carries his musical instrument on his back, two harshly toned cymbals, shaped like hollow scales, and who drags his obese body heavily along, ringed with pale green and butter colour, and ending in a long dagger. Place these three species side by side, and own with me that to be able to choose creatures so unlike, and yet keep to the same entomological order, the Sphex must have such an eye as not only a fairly observant person, but a practised entomologist would not be ashamed of.

In the presence of these singular predilections, which seem to have limits laid down by some master of classification,—a Latreille for instance—it becomes interesting to inquire if foreign Sphegidæ hunt game of the same order. Unfortunately information as to this is scanty or absolutely *nil* as regards most species. This regrettable lack is chiefly caused by the superficial method generally adopted. An insect is caught, transfixed with a long pin, fastened in a box with a cork bottom; a ticket with a Latin name is put under its feet, and all is said. This way of looking at entomological history does not satisfy me. It is useless to tell me that such a species has so many joints in its antennæ, so many nerves in its wings, so many hairs on a part of the abdomen or thorax; I do not really know the creature until I have learned its manner of life, its instincts and habits. And observe what a luminous superiority has a description of the latter kind, given in two or three words over long descriptions, sometimes so hard to understand. Let us suppose that you want to introduce Sphex occitanica to me;

you describe the number and arrangement of the wing nerves, and you speak of cubital and recurrent nerves; next follows the written description of the insect. Here it is black, there rusty red, smoky brown at the wing tips, at such a spot it is black velvet, at another silvery down, and at a third smooth. It is all very precise, very minute—one must grant that much justice to the clear-sighted patience of him who describes; but it is very long, and besides, not always easy to follow, to such a degree that one may be excused for being sometimes a little bewildered, even when not altogether a novice. But add to the tedious description just this—hunts ephippigers, and with these two words light shines at once; there can be no mistake about my Sphex, none other selecting that prey. And to illuminate the subject thus, what was needed? Real observation, and not to let entomology consist in rows of impaled insects. But let us pass on and consider such little as is known as to the manner in which foreign Sphegidæ hunt. I open Lepeletier de St. Fargeau's *History of Hymenoptera*, and find that on the other side of the Mediterranean, in our Algerian provinces, S. flavipennis and S. albisecta have the same tastes that characterise them here. In the land of palms they catch Orthoptera just as they do in the land of olives. Although separated by the width of the sea, these sporting fellow citizens of the Kabyle and the Berber hunt the same game as their relatives in Provence. I see mentioned a fourth species, S. afra, as hunting crickets round Oran. Moreover, I have a recollection of having read—I know not where—of a fifth

species, which makes war on crickets upon the steppes in the neighbourhood of the Caspian Sea. Thus in the lands bordering the Mediterranean we have five different species whose larvæ all live on Orthoptera.

Now let us cross the equator, and descend in the other hemisphere to the Mauritius and Réunion Islands, and we shall find, not a Sphex but a Hymenopteron, nearly allied, of the same tribe, Chlorion or Ampulex, chasing the horrid kakerlacs, the curse of merchandise in ships and colonial ports. These kakerlacs are none other than cockroaches, one species of which haunts our houses. Who does not know this stinking insect, which, thanks to its flat shape, like that of an enormous bug, insinuates itself into gaps in furniture and partitions, and swarms everywhere that there is food to devour. Such is the cockroach of our houses—a disgusting likeness of the not less disgusting prey beloved by the Chlorion. Why does a near relation of our Sphex select the kakerlac as prey. The reason is simple: With its buglike form the kakerlac is an Orthopteron by the same rights as the grasshopper, ephippiger, and cricket. From these six examples, the only ones known to me, and from such widely distant localities, may we not conclude that all Sphegidæ hunt Orthoptera? Without adopting so sweeping a conclusion, one at least sees what the usual food of their larvæ must be.

There is a reason for this surprising choice. What is it? What motives fix a diet which in the strict limits of one and the same entomological order is now composed of ill-smelling kakerlacs, now

of dry, but well-flavoured crickets, and in yet another of plump grasshoppers, or corpulent ephippigers? I confess that to me it is incomprehensible, and I leave the problem to others. Observe, however, that the Orthoptera rank among insects as the ruminants do among mammalia. Endowed with a mighty paunch and a placid character, they feed on herbage, and easily get corpulent. They are numerous and met with everywhere, slow of gait, and thus easy to catch, and, moreover, of a size just right for prey. Who can say if the Sphegidæ—vigorous hunters which require a large prey—do not find in these ruminants among insects what we find in our domestic ruminants—the sheep and ox, peaceful victims rich in flesh? This is, however, a mere supposition.

I have more than a supposition in another case, equally important. Do the consumers of Orthoptera ever vary their diet? Should their favourite game fail, can they do with another? Does S. occitanica think that except a fat ephippiger, there is nothing in the wide world worth eating. Does S. albisecta admit nothing but crickets to her table, and S. flavipennis only grasshoppers? Or according to time, place, and circumstance, does each replace the favourite food by some equivalent? It would be of the highest importance to bring forward such facts if they exist, as they would tell us whether the suggestions of instinct are absolute and immutable, or if they vary, and within what limits. It is true that in the cell of a Cerceris are buried most varied species of Buprestids or of the Weevil group, which shows that she has a great latitude of choice;

SPHEX FLAVIPENNIS ABOUT TO SEIZE GRASSHOPPER

[*To face p.* 120.

but such an extension of hunting ground cannot be supposed for the Sphex, which I have found so faithful to one exclusive prey, invariable for each species, and which, moreover, finds among the Orthoptera kinds of very different shapes. I have, however, had the good fortune to meet with one case—only one—of complete change in the larva's food, and I mention it the more willingly in the archives of the Sphegidæ because such facts, scrupulously observed, will one day be corner-stones for him who may desire to build the psychology of instinct on solid foundations.

This is my fact. The scene is on a jetty by the Rhône. On one side is the great river, with its thunder of waters, on the other, a dense thicket of osiers, willows, and reeds, and between the two a narrow path with a bed of fine sand. A yellow-winged Sphex appears, hopping and dragging its prey along. What do I see! It is no grasshopper, but a common Acridian! And yet the Hymenopteron really is the Sphex so well known to me (S. flavipennis), the energetic huntress of grasshoppers! I can hardly believe my eyes. The burrow is not far off; she enters and stores her booty. I seat myself, determined to await a new expedition — wait hours if need be to see if so extraordinary a capture is repeated. Seated there I occupy the whole width of the path. Two simple conscripts come up, new-clipped, with that incomparable, automaton-look conferred by the first days of barrack life. They are chattering together—no doubt talking of their homes and the girls they left behind them; each is peeling a willow switch with a

knife. A fear seizes me; ah! it is not easy to try an experiment on the public way, where, when some fact watched for during long years does present itself, a passer-by may disturb or annihilate chances which may never occur again! I rise anxiously to make way for the conscripts; I withdraw into the osier bed, and leave the narrow way free. To do more was not prudent; to say, "My good fellows, do not go that way," would have made bad worse. They would have supposed some snare hidden in the sand, and questions would have arisen to which no reply that would satisfy them could have been given. My request, moreover, would have turned these idlers into lookers-on, very embarrassing company in such studies, so I resolved to say nothing, and trust to my luck. Alas! alas! my star betrayed me. The heavy regulation boot was planted exactly on the Sphex's roof. A shudder ran through me as though I had myself received the impress of the iron heel.

The conscripts gone I proceeded to the salvage of the contents of the ruined burrow. There was the Sphex mutilated by the pressure, and there were not only the cricket which I saw carried down, but two others—three crickets in all instead of the usual grasshoppers. What was the reason of this strange variation? Were there no grasshoppers near the burrow, and did the distressed Hymenopteron do the best she could with Acridians—contenting herself as it were with blackbirds for want of thrushes, as the proverb says? I hesitate to believe it, for there was nothing in the neighbourhood to denote absence of her favourite game. Some happier means may

unriddle this new problem. In any case S. flavipennis, either from imperious necessity, or from motives unknown to me, sometimes replaces her favourite prey, the grasshopper, by another, the Acridian, altogether unlike outwardly to the former, but still an Orthopteron.

The observer on whose authority Lepeletier de St. Fargeau speaks of this Sphex's habits witnessed in Africa, near Oran, a similar storing of Acridians. S. flavipennis was surprised by him dragging along an Acridian. Was it an accidental case, like the one seen by me on the banks of the Rhône? Was it the exception, or was it the rule? Were grasshoppers wanting around Oran, and did the Hymenopteron replace them by Acridians? Circumstances compel me to ask the question without finding a reply.

Here should be interpolated a certain passage from Lacordaire's *Introduction to Entomology*,[1] against which I long to raise my voice in protest. Here it is: "Darwin, who has written a book on purpose to prove the identity of the intellectual principle which produces action in man and animals, walking one day in his garden noticed on the ground in a shady walk a Sphex which had just caught a fly nearly as big as itself. He saw it cut off with its mandibles the victim's head and abdomen, keeping only the thorax, to which the wings remained attached. It then flew away, but a breath of wind striking the fly's wings twirled the Sphex round,

[1] In a later essay, *Fragments on Psychology*, M. Fabre withdraws these strictures on (Erasmus) Darwin, explaining that they are based on a misquotation by Lacordaire, who writes "Sphex" where Darwin had said "wasp."

and hindered its progress. Thereupon it lit again on the walk, cut off first one wing and then the other from the fly, and having thus removed the cause of its difficulties, flew off with the remainder of its prey. This fact indicates manifest signs of reasoning. Instinct might have induced the Sphex to cut off the wings of its victim before transporting it to the nest, as do some species of the same genus, but here were consecutive ideas and results of those ideas quite inexplicable, unless one admits the intervention of reason."

This little story, which so lightly bestows reason on an insect, is wanting not only in truth but in mere probability—not in the act itself, which I do not question at all, but in its motives. Darwin saw what he relates, but he was mistaken as to the hero of the drama; as to the drama itself, and as to its meaning—profoundly mistaken, and I can prove it.

First and foremost the old English savant ought to have known enough about the creatures which he so freely ennobles to call things by their right name. Let us therefore take the word Sphex in its strictly scientific sense. Then by what strange aberration does this English Sphex, if English ones there are, choose a fly as its prey when its fellows hunt such different game—namely, Orthoptera? And even if we grant, what I consider inadmissible, a Sphex catching flies, other difficulties crowd in. It is now proved on evidence that the burrowing Hymenoptera do not carry dead bodies to their larvæ, but merely prey benumbed and paralysed. What, then, is the meaning of this prey whose head, abdomen, and wings are cut off? The torso carried away is but a

portion of a corpse that would infect the cell and be useless to the larva, not yet to be hatched for several days. It is perfectly clear that Darwin's insect was not a Sphex, strictly speaking. What, then, did he see? The word fly, by which the captured prey is designated, is a very vague term which might be applied to the greater part of the immense order of Diptera, and therefore leaves us uncertain among thousands of species. Probably the name of Sphex is used equally vaguely. When Darwin's book appeared, not only the real Sphegidæ were so called, but also the Crabronides. Now among these last some provide their larvæ with Diptera, the prey required for the unknown Hymenopteron of the English naturalist. Was then Darwin's Sphex a Crabro? No, for these hunters of Diptera, like the hunters of any other game, require prey which will keep fresh and motionless, but half alive for the fortnight or three weeks needed before the eggs hatch, and for the complete development of the larvæ. These little ogres require meat not decayed, nor even high, but fresh. I know no exception to this rule, and therefore the name Sphex cannot have been used in its old meaning.

Instead of dealing with a precise fact, really worthy of science, we have an enigma to find out. Let us continue to examine it. Several of the Crabronides are so like wasps in figure and form and shape and their yellow and black livery, that they might deceive any eye unpractised in the delicate distinctions of entomology. In the eyes of every one who has not made a special study of the subject, a Crabro is a wasp. Is it not possible that the English observer,

regarding things from a lofty height, and considering unworthy of close examination the petty fact, which, however, was to serve to corroborate his transcendent views and grant reason to animals, may have in his turn committed an error, conversely and very excusably, by taking a wasp for one of the Crabronides? I could almost declare it is so, and for the following reasons. Wasps, if not always at any rate frequently, bring up their family on animal food, but instead of provisioning each cell they distribute nourishment singly to the larvæ, and several times in the day; feeding them from their mouths with soft pap, as the father and mother do young birds. This pap consists of mashed insects, ground down in the jaws of the nursing wasp; the insects preferred for it are Diptera, especially the common fly; if fresh meat offers itself it is largely used. Who has not seen wasps penetrate into our kitchens, or dart on the joints in a butcher's shop, cut off some scrap of flesh which suits them, and carry away a tiny spoil for the use of their larvæ? When half-closed shutters allow a ray of light to fall on the floor of a room where the house-fly is taking a comfortable nap, or brushing its wings, who has not seen a wasp suddenly enter, pounce upon it, crush it in its jaws, and flee with the booty? This again is a dainty meal for the carnivorous nurslings. Sometimes the prey is at once dismembered, sometimes on the way, sometimes at the nest. The wings, in which there is no nourishment, are cut off and rejected; the feet, poor in juices, are also sometimes disdained. There remains a mutilated corpse, head, thorax, abdomen, or part thereof, which

the wasp chews repeatedly to reduce into a pap for the larvæ to feast on. I have tried to bring up larvæ myself on fly-paste. The experiment was tried on a nest of Polistes gallica, the wasp which fixes her little rose-shaped nest of gray paper cells on the bough of some shrub. My kitchen apparatus was a piece of marble slab, on which I crushed up the fly-paste after cleaning my game—in other words, having taken away the parts which were too tough—wings and feet; and the feeding-spoon was a slender straw, at the end of which, going from cell to cell, I handed the food to larvæ, which opened their mouths just like young birds in a nest. I did just the same and succeeded just as well in the days when I used to bring up broods of sparrows—that joy of childhood! All went on as well as heart could wish as long as my patience held out against the trials of a bringing up so absorbing and full of small cares.

The obscurity of the enigma is replaced by the full light of truth, thanks to the following observation, made with all the leisure that a strict precision demands. In the first days of October two great clumps of blossoming asters at the door of my study became the rendezvous of a quantity of insects, among which the hive bee and Eristalis tenax were the most numerous. A gentle murmur arose from them, like that of which Virgil wrote, "Sæpe levi somnum suadebit inire susurro." But if the poet finds in it only an invitation to slumber, the naturalist finds a subject for study; these small folk luxuriating on the last flowers of the year may perhaps afford him some new information. So I

am on the watch before the two clumps with their countless lilac corollas.

The air is perfectly still; the sun burns, the air is heavy—all signs of a coming storm; but these are conditions eminently favourable to the labours of the Hymenoptera, which seem to foresee to-morrow's rain, and redouble their activity in turning the present hour to profit. The bees work ardently; the Eristalis fly clumsily from flower to flower. Now and then, into the midst of the peaceable throng who are swilling nectar, bursts a wasp, insect of rapine, attracted there by prey, not honey.

Equally ardent in carnage, but unequal in strength, two species divide the chase; the common wasp, Vespa vulgaris, which catches Eristalis, and the hornet, V. crabro, which hunts hive bees. Both carry on the chase in the same way. They fly fast backwards and forwards over the flowers, and suddenly throw themselves on the prey which is on its guard and flies off, while their impulse carries them headfirst against the deserted flower. Then the chase is continued in the air, just as a sparrowhawk hunts a lark. But bee and Eristalis foil the wasp by their sudden turns, and it goes back to fly above the blossoms. By and by some insect less swift to escape gets captured. The common wasp instantly drops on the turf with its Eristalis, and I drop down too at the same moment, putting aside with both hands the dead leaves and bits of grass which might hinder my seeing clearly, and this is the drama which I behold, if proper precautions be taken not to scare the wasp.

First there is a wild struggle among the blades of

grass between the wasp and an Eristalis bigger than itself. The Dipteron is unarmed but strong, and a shrill hum tells of desperate resistance. The wasp carries a poignard, but does not know how to use it methodically, and is ignorant of the vulnerable points so well known to the hunters which need flesh that must keep good for a considerable time. What its nurslings want is a paste made of flies newly crushed, so that it matters little how the game is killed. The sting is used blindly—anywhere, pointed at the head, sides, thorax, or under part of the victim, as chance directs while the two wrestle. The Hymenopteron, paralysing its victim, acts like the surgeon, who directs his scalpel with a skilled hand; the wasp when slaying acts like a common assassin stabbing blindly in a struggle. Thus the resistance of the Eristalis is long, and its death rather the result of being cut up by a pair of scissors than of stabs with a dagger. These scissors are the wasp's mandibles, cutting, disembowelling, and dividing. When the game has been garroted and is motionless between the feet of its captor, a bite of the mandibles severs the head from the body; then the wings are shorn off at the junction with the shoulder; the feet follow, cut off one by one; then the abdomen is rejected, but emptied of its interior, which the wasp appears to preserve with her favourite part, the thorax, which is richer in muscle than the rest of the Eristalis. Without further delay she flies off, carrying it between her feet. Having reached the nest she will mash it up and distribute it to the larvæ.

The hornet having seized a bee acts almost in the same way, but it is a giant of a robber, and the

fight cannot last long, despite the sting of the victim. Upon the very flower where the capture was made, or oftener on some twig of a neighbouring shrub, the hornet prepares its dish. First of all the bag of the bee is torn open, and the honey lapped up. The prize is thus twofold—that of a drop of honey, and the bee itself for the larvæ to feast on. Sometimes the wings are detached, as well as the abdomen, but generally the hornet is contented with making a shapeless mass of the bee which is carried off whole. It is at the nest that the parts valueless for food are rejected, especially the wings. Or the paste may be prepared on the spot, the bee being crushed at once between the hornet's mandibles, after wings, feet, and sometimes the abdomen are cut off.

Here, then, in all its details is the fact observed by Darwin. A wasp, Vespa vulgaris, seizes Eristalis tenax; with her mandibles she cuts off head, wings, and abdomen of the victim, keeping only the thorax, with which she flies away. But we need no breath of air to explain why they were cut off; the scene takes place in perfect shelter, in the grass. The captor rejects such parts as are useless for the larvæ, and that is all.

In short, a wasp is certainly the heroine of Darwin's story. What, then, becomes of that reasoning which made the creature, in order better to contend with the wind, deprive its prey of abdomen, head, and wings, leaving only a thorax? It becomes a very simple fact, whence flow none of the great consequences that were drawn from it,—the very trivial fact that a wasp began at once to cut up her prey, and only considered the trunk worthy

of her larvæ. Far from discovering the least indication of reasoning, I see only an act of instinct so elementary that it is really not worth consideration.

To abase man and exalt animals in order to establish a point of contact, then a point of fusion,—such has been the usual system of the advanced theories now in fashion. Ah! how often do we not find in these sublime theories that are a sickly craze of our day, proofs peremptorily asserted, which under the light of experiment would appear as absurd as the Sphex of the learned Erasmus Darwin!

X

THE SPHEX OF LANGUEDOC

WHEN the chemist has ripely considered his plan of research, he mixes his reactives at whatever moment suits him best, and sets his retorts on the fire. He is master of time, place, and circumstance, chooses his own hour, isolates himself in his laboratory, where he will be undisturbed, and brings about such or such conditions as reflexion may suggest. He is searching out the secrets of brute nature, whose chemical activities science can arouse at will.

The secrets of living nature—not those of anatomy, but those of life in action, especially of instinct—offer conditions far more difficult and delicate to the observer. Far from being able to take his own time, he is the slave of season, day, or hour, even of the moment. If an opportunity offer, it must be seized at once—it may be very long ere it comes again. And as it usually comes just when one is thinking least about it, nothing is ready whereby to turn it to account. One must improvise there and then one's little means of experiment, combine one's plan, devise one's wiles, imagine one's tactics, and feel only too fortunate if inspiration come quickly enough to

allow one to profit by the chance offered. Moreover, such chances come only to one who looks out for them, watches for days and days,—here on sandy slopes exposed to the burning sun, there in the cauldron of some path enclosed by high banks, or on some shelf of sandstone, the solidity of which is not always such as to inspire confidence. If it be granted you to set up your observatory under the scanty shade of an olive that you may think will shelter you from a pitiless sun, then bless the fate which is treating you like a sybarite ; your lot is in Eden. Above all—keep a sharp lookout. The spot is promising, and who knows? Any moment the chance may come.

It has come! tardily, it is true, but it has come. Ah! could one but observe now, in the peace of one's study, isolated, absorbed, thinking only of what one is studying, far from the profane passer-by who will stop, seeing you so preoccupied where he sees nothing, will overwhelm you with questions and take you for a diviner of springs with the magic hazel wand, or worse, as a doubtful character, seeking by incantations old pots full of money hidden underground. Even if you seem to him to have the look of a Christian, he will come near, look at what you are looking at, and smile in a fashion which leaves no possible doubt as to his humble opinion of people who spend their time in watching flies. You would only be too happy if this annoying visitor would depart, laughing in his sleeve, but without disturbing everything and repeating the disaster caused by the soles of my two conscripts.

Or if it is not the passer-by who is perplexed by

your unaccountable proceedings, it will be the garde-champêtre, that inexorable representative of the law amid the fallow fields. Long has he had his eye upon you. He has so often seen you wandering like a troubled ghost for no reason that he can perceive; has so often caught you seeking something in the ground, or knocking down some bit of wall in some hollow way with infinite precaution that he begins to look on you as a suspicious character, a vagabond, a gipsy, a tramp, or, at all events, a maniac. If you have a botanical tin, to him it is the ferret-cage of the poacher, and it will be impossible to convince him that you are not destroying all the rabbits in the neighbouring warrens, regardless of the laws of the chase and the rights of the owner. Beware! However thirsty you may be, lay no finger on a cluster in the vineyard hard by; the man of the municipal livery would be there, delighted to bear witness and get at last an explanation of your exasperatingly perplexing conduct.

I must do myself the justice to say that I have never committed such a misdeed, and yet one day when I was lying on the sand, absorbed in the domestic affairs of a Bembex, I heard beside me, "In the name of the law, I summon you to follow me!" It was the garde-champêtre of Les Angles, who having vainly watched for an opportunity of catching me in some offence, and being daily more desirous of an answer to the riddle which tormented him, had finally decided on a summons. An explanation became necessary. The poor man did not appear in the least convinced. "Bah! bah!" said he, "you'll never get me to believe that you come and roast

yourself in the sun just to watch flies. I keep my eye on you, you know, and the first time. . . . Well, that's enough." He departed. I have always believed that my red ribbon had a good deal to do with this departure, and I ascribe to that ribbon other similar services during my botanical or entomological rambles. It seemed to me—was it an illusion?—it did seem to me that during my botanical expeditions on Mont Ventoux, the guide was more manageable than usual and the donkey less obstinate.

The little dark red ribbon has not always protected me from the tribulations the entomologist must expect when carrying on experiments upon the highway. Since dawn I had been lying in ambush at the bottom of a ravine; Sphex occitanica was the object of my early visit. A party of three women vintagers passed on their way to work. A glance was cast on the seated figure apparently lost in thought. "Good day" was politely offered and politely answered. At sunset the women returned with full baskets. The man was still there, seated on the same stone, his eyes fixed on the same spot. My motionless figure, my persistent stay in that lonely place, must have struck them greatly. As they passed I saw one tap her forehead, and heard her whisper, "A poor innocent, *pécaïre!* a poor innocent!" and all three made the sign of the cross.

An innocent, an idiot, a poor inoffensive creature who is deficient; and all three crossed themselves—an idiot being one to them marked by God's seal. "How?" said I. "What cruel mockery of fate! You who are labouring to discover what is instinct and what reason in the animal; you yourself are a

half-wit in the eyes of these women! What humiliation! However, *pècaïre*, that term of supreme commiseration in Provençal, uttered from the bottom of the heart, made me quickly forget the *Innocent*."

It is to that same ravine that I invite my reader, if he is not repelled by the small annoyances of which I have given him a foretaste. S. occitanica haunts these parts, not in numbers giving one another rendezvous when nidification is going on, but solitary individuals far apart, wherever their vagabond peregrinations have led them. Just as their relative S. flavipennis seeks the society of relations and the animation of a work-yard and company, so, on the other hand, does the Languedocian Sphex prefer calm, isolation, and solitude. Graver in behaviour, more formal in manner, more elegant of figure, and in more sombre attire, she always lives apart, careless of what others are doing, disdaining companionship, a very misanthrope among Sphegidæ. S. flavipennis is sociable; S. occitanica is unsociable—a profound difference, alone sufficient to characterise them.

This suggests how greatly the difficulty of observing the latter is increased. No long meditated experiment is possible, nor can one attempt to repeat it a second time if the first has failed. If you make preparations beforehand,—for instance, if you put in reserve a piece of game to substitute for that of the Sphex,—it is to be feared, indeed it is almost certain, that she will not appear, or if she comes, your preparations turn out useless. Everything must be improvised at once—conditions which I have not always been able to realise as I could have wished.

Let us take courage; the position is good.

SPHEX OCCITANICA TAKING A SUN BATH

[To face p. 136.

Many a time I have here surprised the Sphex reposing on a vine-leaf, exposed to the full rays of the sun. The insect, lying flat and spread out, is voluptuously enjoying the delights of warmth and light. From time to time a kind of frenzy of pleasure bursts forth in her; she thrills with well-being, drums rapidly on her resting-place with the points of her feet, and produces a sound somewhat like the roll of a drum, or heavy rain falling on foliage perpendicularly. You may hear this joyous drumming several paces off. Then again comes perfect stillness, followed by a fresh nervous commotion, and that waving of tarsi which is a sign of supreme happiness. I have known some of these ardent sun-worshippers suddenly leave a half-finished burrow to settle on a neighbouring vine and take a bath of sun and light, returning reluctantly to give a careless sweep to the hole, and finally abandon the workshop, unable longer to resist the temptation of luxuriating on a vine leaf. Perhaps this voluptuous resting-place is also an observatory whence to inspect the neighbourhood, and espy and choose prey. This Sphex catches only the ephippiger of the vine, scattered here and there on the leaves or on any convenient bush. The game is succulent—all the more that only females full of eggs are selected.

Let us pass over numerous expeditions, fruitless researches, and the tedium of long waiting, and present the Sphex to the reader just as she shows herself to the observer. Here she is, at the bottom of a hollow way with high sandy banks. She comes on foot, but aids herself with her wings in dragging along her heavy captive. The ephippiger's antennæ, like

long fine threads, are the harness ropes. With her mandibles and holding her head high, she grasps one of them, passing it between her feet, and the prey is dragged on its back. If some unevenness of ground should oppose itself to this style of haulage, she stops, clasps the ample provender, and transports it by very short flights, going on foot between whiles whenever this is possible. One never sees her undertake sustained flights for long distances carrying prey, as do those strong cruisers, the Bembex and Cerceris, which will carry perhaps for a good half mile through the air, the former their Diptera, the latter their weevils—very light prey compared with the huge ephippiger. The overwhelming size of its captive forces S. occitanica to convey it along the ground—a means of transit both slow and difficult. The same reason—namely, the great size and weight of the prey—entirely upsets the usual order followed by the Hymenoptera, in their labours,—an order well known, and consisting in first hollowing a burrow and then victualling it. The prey not being disproportioned to the size of the spoiler, facility of transport by flight allows the Hymenopteron a choice as to the position of her domicile. What matter if she has to hunt at considerable distances? Having made a capture, she returns home with rapid flight; it is indifferent to her whether she is near or far. Therefore she prefers the spot where she was born, and where her predecessors have lived; there she inherits deep galleries, the accumulated labour of former generations; with a little repair they can be used as avenues to new chambers, better defended than would be a

single excavation a little below the surface made annually. Such is the case with Cerceris tuberculata and Philanthus apivorus, and even if the inherited dwelling should not be solid enough to resist wind and weather from one year's end to another, and to be handed down to the next generation, at all events the Hymenopteron finds conditions of greater safety in spots consecrated by ancestral experience. There she hollows out galleries, each serving as corridors to a group of cells, thus economising the labour to be expended on the entire egg-laying.

In this way are formed, not true societies, there being no concerted effort to a common end, but at least gatherings where the sight of other Sphegidæ no doubt animates the labour of each. In fact, one can notice between these small tribes, sprung from one and the same stock, and the solitary miners, a difference in activity, recalling in one case the emulation of a populous workshop, and in the other the dulness of labourers in the tedium of isolation. For the animal as well as man activity is contagious, and excited by its own example. Let us sum up. Where there is a moderate weight for the spoiler, it is possible to carry it on the wing for a great distance, and then the Hymenopteron can arrange the burrows at pleasure, choosing by preference its birthplace. From this preference of the birthplace results an agglomeration—a coming together of insects of the same species, whence arises emulation in their work. This first step towards social life is the result of easy journeys. Is it not so with man? excuse the comparison! Men, where ways are bad,

build solitary cottages, while where there are good roads, they collect in populous cities, served by railroads, which, so to say, annihilate distance; they assemble in immense human hives called London or Paris.

The Languedocian Sphex has quite another lot. Its prey is a heavy ephippiger—a single morsel representing the whole sum of provender amassed by the other predatory insects bit by bit. What the Cerceris and other strong-flying insects do by dividing their labour is accomplished by a single effort. The weight of the prey rendering flight impossible, it must be brought home with all the delays and fatigue of dragging it along the ground. This one fact obliges her to accommodate the position of her burrow to the chances of the chase: first the prey and then the dwelling. Hence no rendezvous at a general meeting-place; no living among neighbours, no tribes stimulating themselves by mutual example—only isolation where chance has led the Sphex—solitary labour, unenthusiastic, though always conscientious. First of all prey is sought, attacked, and paralysed. Then comes making the burrow. A favourable spot is chosen as near as possible to that where lies the victim, so as to abridge the toil of transport, and the cell of the future larva is rapidly hollowed to receive an egg and food as soon as possible. Such is the very different method shown by all my observations. I will mention the chief of them.

If surprised in its mining, one always finds this Sphex alone—sometimes at the bottom of some dusty niche a fallen stone has left in an old wall—

sometimes in a shelter formed by a projecting bit of sandstone, such as is sought by the fierce-eyed lizard as a vestibule to its retreat. The sun falls full upon it; the place is a furnace. The soil is extremely easy to hollow, formed as it is by ancient dust which has dropped little by little from the roof. The mandibles, which act as pincers to dig with, and the tarsi, as rakes to clear away, soon hollow the cavity. Then the Sphex flies off, but in a leisurely way, and without any great expenditure of wing power, a manifest sign that the expedition is not a long one. One's eye can easily follow the insect and discover where it alights, usually some ten yards off. Sometimes it decides to go on foot. It sets out, hurrying to a spot where we will be indiscreet enough to follow, our presence noways troubling it. Having arrived on foot or on the wing it hunts about for a while, as one may conclude from its indecision and short excursions on all sides. It seeks and at last finds, or rather finds anew. The object found is an ephippiger, half-paralysed, but still moving antennæ, tarsi, and ovipositor—a victim which the Sphex certainly poignarded a little while before with several stings, and then left her prey, an embarrassing burden, while she still hesitated as to the choice of a domicile. Perhaps she abandoned it on the very spot of the capture, leaving it rather obvious on a grass tuft the better to find it later, and trusting to her good memory to return where lies the booty, set to work to explore the neighbourhood and find a suitable spot to burrow. This done she came back for the game which was found without much hesitation, and now she prepares to convey it home.

She bestrides the insect, seizes one or both antennæ and sets off, pulling and dragging with all the strength of loins and jaws.

Sometimes the journey is accomplished at one trial; more frequently she leaves her load and hurries home. Perhaps it occurs to her that the entrance door is not wide enough for this ample morsel, perhaps she bethinks her of some defect of detail that might interfere with provisioning the cell. Yes, she retouches her work, enlarges the doorway, levels the threshold, consolidates the arch, all with a few sweeps of the tarsi. Then she returns to the ephippiger, lying on its back a few paces distant, and drags it on again. But a new idea seems to flash across her lively mind. She had visited the gateway but had not looked within; who knows if all be well there? She hastens back, leaving the ephippiger midway. The interior is visited, and apparently some touches as with a trowel are given by the tarsi, to lend a last finish to the walls. Without lingering over these final touches the Sphex returns to her prey, and harnesses herself to the antennæ. Forward! Will the journey be accomplished this time? I would not answer for it. I have known a Sphex, perhaps more suspicious than others, or more forgetful of the minor details of architecture, set her omissions right or allay her suspicions by abandoning her prey five or six times successively, and hurrying to the burrow, which each time was touched up a little or simply entered. It is true that others go straight home, without even stopping to rest. I must add that when the Sphex comes home to perfect her dwelling, she does not

fail to give an occasional, distant glance at the ephippiger left on the way, to make sure that nothing touches it. This prudence recalls that of the Scarabæus sacer issuing from the hole which it is digging to feel its dear ball, and bring it a little nearer.

The deduction to be drawn from the facts just stated is evident. Since every Sphex occitanica we surprise while it burrows—be it at the very beginning, at the first stroke of her tarsi in the dust, or later, the dwelling being ready—makes a short expedition on foot or on the wing, and always finds a victim already stabbed, already paralysed, one may conclude with certainty that she first makes her capture, and later burrows, so that the place of capture decides that of the domicile.

This reversal of method which prepares the food before the larder, while previously we saw the larder precede the food, I attribute to the weight of the prey being too great to carry on the wing. It is not that S. occitanica is ill-organised for flight ; on the contrary, she can soar splendidly, but her prey would overwhelm her if she depended only on her wings. She needs the support of the ground and must drag her prey, and displays wonderful vigour in doing this. Loaded with prey she always goes on foot, or takes very short flights when these spare time and toil. Let me quote an instance taken from my latest observations on this curious Hymenopteron.

A Sphex appeared suddenly, whence I know not, dragging an ephippiger apparently just caught hard by. As things were she had to burrow, but the position was as bad as possible—a highway, hard as

stone. There was no time for difficult mining, since the prey must be stored as soon as possible; she needed light soil where the cell could be quickly made. I have already described her favourite soil—dust deposed by years at the bottom of some hole in a wall, or in some little hollow of a rock. The Sphex which I was observing stopped at the foot of a country house with a newly whitewashed façade, and measuring from six to eight metres in height. Instinct told her that under the roof tiles she would find hollows rich in ancient dust. Leaving her prey at the foot of the façade, she flew on to the roof. For some time I saw her seek vainly about. Then, having found a suitable position, she set to work under the hollow of a tile. In ten minutes or a quarter of an hour at most the domicile was ready; she flew down, promptly found the ephippiger, and then had to carry up her prey. Would it be on the wing, as circumstances suggest? Not at all; the Sphex adopted the difficult method of escalading a vertical wall with a surface smoothed by the mason's trowel and from six to eight metres high. Seeing her take this road, dragging her game between her feet, I thought at first that it was impossible, but was soon reassured as to the outcome of this audacious attempt. Supporting herself by the little roughnesses of the mortar, the vigorous insect, in spite of the embarrassment of her heavy load, made her way up this vertical plane with the same security, the same speed, as on horizontal ground. The top is reached without any hindrance, and the prey provisionally deposited at the edge of the roof on the rounded bark of a tile. While the Sphex was retouching her

burrow the ill-balanced prey slipped and fell to the foot of the wall. She must begin again, and again by means of an escalade. The same imprudence is repeated; once more left on the curved tile the prey slips and falls to the ground. With a calm which such accidents cannot disturb, the Sphex for the third time hoists the ephippiger by climbing the wall, and, better advised, drags it straight to the bottom of the hole.

If carrying the prey on the wing has not been attempted even in such conditions as the above, it is clear that the Sphex is incapable of flight with so heavy a load. To this impotence we owe the few details of habits which are the subject of this chapter. A prey not too heavy to be carried on the wing makes a semi-sociable species of S. flavipennis—that is to say, one seeking the company of its fellows; a heavy prey impossible to carry through the air renders S. occitanica a species devoted to solitary labour—a kind of savage, disdainful of the solace derived from neighbourhood of one's fellows. The greater or lesser weight of their prey decides the fundamental character.

XI

THE SCIENCE OF INSTINCT

I HAVE no doubt that in order to paralyse her prey, Sphex occitanica follows the method of the one that hunts grasshoppers, plunging her sting repeatedly into the breast of the ephippiger in order to reach the thoracic ganglia. She must be familiar with the operation of injuring the nerve centres, and I am assured beforehand of her consummate skill in the learned operation. It is an art familiar to all the predatory Hymenoptera who bear a poisoned dagger, and it is not given them for nothing. But I must own that I have never yet beheld the deadly manœuvre, thanks to the solitary life of this Sphex.

When a number of burrows are made and then provisioned on some common ground, one has only to wait there to see now one insect return from the chase, now another, with her prey, and it is easy to substitute a live victim for the one sacrificed, renewing the experiment at will. Besides, the certainty that the subjects for experiment will not fail when wanted allows everything to be prepared beforehand, while with S. occitanica these conditions of success do not exist. To set out and look for her with one's

preparations made is all but useless, so sparsely are these solitary insects scattered. Moreover, if you do meet with one, it will probably be during her idle hour when nothing is to be learned. I repeat that it is almost always unexpectedly, when you are not thinking about it, that the Sphex appears with her ephippiger. This is the moment—the one propitious moment—to attempt a substitution of prey and to induce her to let you witness those dagger thrusts. Let us hasten; time presses; in a few moments the burrow will have enclosed the provender, and the grand chance will be lost.

Need I speak of my mortification in these promising moments—a mocking lure offered by fortune! Under my eyes is matter for curious observations, and I cannot profit by it! I cannot steal the Sphex's secret, for I have no equivalent to offer for her prey. Just try, if you like, to go about looking for an ephippiger when there are but a few minutes to find it in! Why, it took me three days of wild search before I could find weevils for my Cerceris! Yet twice did I make that desperate attempt. Ah! if the garde-champêtre had caught me then rushing about the vineyards, what a chance he would have had to believe me guilty of theft, and of reporting me! Vines and grapes—nothing was respected by my hurried steps, fettered by the vine garlands. I must and would have an ephippiger, and have it then and there. And once I did find one during one of these rapid expeditions. I beamed with joy, little foreseeing the bitter disappointment awaiting me.

If only I can come in time! if only the Sphex is

still dragging her victim! Thank heaven! all favours me. She is still at some distance from her hole, and is bringing along her prey. With my pincers I gently draw it back. She resists, clutches the antennæ and will not let go. I pull harder, even making her go backwards; it is in vain, she holds on. I had with me a pair of delicate little scissors, part of my entomological outfit, and I rapidly cut the harness, otherwise the long antennæ of the ephippiger. The Sphex still advanced, but soon paused, surprised by the sudden lightening of her load, which now indeed only consisted of the antennæ detached by my malicious artifice. The real burden, the heavy-bodied insect, remained behind, instantly replaced by my living one. The Sphex turned, let go the ropes, which now drew nothing, and retraced her steps. Now she is face to face with the prey substituted for her own. She examines it, walks round it with suspicious caution, stops, wets her foot with saliva and washes her eyes. While thus meditating does she say to herself something of this kind: "Well, am I awake or am I asleep? Do I see clearly or not? This thing is not mine. Of what or whom am I the dupe?" At all events she is in no haste to bite my prey. She holds aloof, and shows not the smallest wish to seize it. To excite her I offered the insect with the tips of my fingers, putting the antennæ almost in her jaws, well aware of her audacious tameness, and that she will take from your fingers prey withdrawn and then offered. What is this? She draws back, disdaining my offers and the prey put within her reach. I put down the ephippiger, which, unconscious of danger, goes

straight to its assassin. Now for it. Alas! no; the Sphex continues to draw back, behaves like a veritable coward, and finally takes wing. I never saw her again. Thus ended to my confusion an experiment which had so excited my enthusiasm.

Later, and gradually, as I visited more burrows I came to understand my want of success and the obstinate refusal of the Sphex. I always, without exception, found stored a female ephippiger with an abundant and succulent store of eggs inside her. This, it would seem, is the favourite food of the larvæ. In my rush among the vines I had laid hands on one of the other sex. It was a male which I offered to the Sphex! More clear-sighted than I in the great victualling question, she would have nothing to say to my game. "A male! Is that the kind of dinner for my larvæ? And, pray, for whom do you take them?" How sensitive must be these dainty eaters who appreciate the difference between the tender flesh of the female and the comparatively dry body of the male! What a penetrating glance which can distinguish instantly the one sex from the other, though alike in form and colour! The female has an ovipositor to bury her eggs with, and this is almost the only outward difference between her and the male. This difference never escapes the keen-sighted Spex, and that is why my experiment made her rub her eyes, immensely puzzled by a prey without an ovipositor, which she was perfectly sure had one when it was caught. At such a transformation what must have passed in her little Sphex brain?

Now let us follow her when, the burrow being ready, she returns to find her victim, deserted not

far from the place of capture, and after the operation which paralysed it. The ephippiger is in a state like that of the cricket slain by S. flavipennis—a certain proof that stings have been darted into the ganglia of the thorax. Nevertheless, many movements continue, but disconnected, though endowed with a certain vigour. Unable to stand, the insect lies on one side or on its back, moving its long antennæ and palpi rapidly, opening and closing its mandibles, and biting as hard as in its normal condition. The abdomen pants fast and deeply; the ovipositor is suddenly brought under the stomach, which it almost touches. The feet move, but languidly and irregularly, the middle ones seemingly more benumbed than the others. If touched with a needle, the whole body starts wildly; efforts are made to rise and walk without success. In short, the creature would be full of life but for the impossibility of locomotion and even of getting on its feet. There is then a paralysis altogether local—paralysis of the feet, or rather partial abolition and ataxy of movement in them. Is this very incomplete inertia caused by some special disposition of the victim's nervous system, or is it that only a single stab is given, instead of wounding each ganglion of the thorax, as does the huntress of grasshoppers? I cannot say.

However, for all its starts, its convulsions, its irregular movements, the victim is none the less unable to harm the larvæ destined to devour it. I have taken from the Sphex's burrow ephippigers struggling just as much as in the first moments of their semi-paralysis, and yet the feeble grub, born but a few hours earlier, was biting the gigantic victim

with entire immunity. This striking result is caused by the mother laying her egg in one particular spot. I have already told how S. flavipennis glues her egg on the cricket's breast, rather on one side, between the first and second pairs of feet. S. albisecta chooses the same place, and S. occitanica an analogous one, rather further back toward the base of one of the large hind thighs, all three thus evincing admirable knowledge as to where the egg will be safe.

For consider the ephippiger shut in the burrow. It is on its back, absolutely incapable of turning over. Vainly does it struggle; the irregular movements of its feet are useless, the cell being too wide for them to gain support from the walls. What do the victim's convulsions matter to the larva? It is on a spot where it cannot be reached by tarsi, mandibles, ovipositor, or antennæ—a point absolutely motionless, where there is not even a shudder of the skin. There is entire security unless the ephippiger can move, turn, and get on its feet, and that one condition is admirably guarded against.

But with several, all in the same degree of paralysis, there would be great risk for the larva. Though there would be nothing to fear from the first insect attacked, as the larva is out of its reach, there would be peril from the neighbourhood of the others, which in stretching out their legs hither and thither might strike it and tear it up with their spurs. Perhaps this is why S. flavipennis, which heaps three or four grasshoppers in one cell, almost entirely paralyses them, while S. occitanica, providing each burrow with a single victim, leaves great power of motion to the ephippiger, simply preventing change

of place or rising to its feet, thus—though I cannot affirm it—economising dagger thrusts.

If the half-paralysed ephippiger be harmless for the larva established on a point of its body where defence is impossible, things are otherwise for the Sphex itself, which has to get it home. First, the prey clutches bits of grass with its tarsi as it is dragged along, being still able to use them pretty freely, causing considerable difficulty in getting it onward. The Sphex, heavily weighted by her load, is exposed to exhaustion by her efforts to make her prey let go its desperate hold on grassy places. But that is the least of the difficulties; it has full use of its mandibles, which snap and bite with their old vigour. Just in front of these terrible pincers is the slender body of the spoiler, as the latter draws the victim along. The antennæ are grasped not far from their root, so that the ephippiger, lying on its back, has its mouth now opposite the abdomen, and now the thorax of the Sphex, who, standing high on her long legs, watches, I am convinced, in order not to be seized by the mandibles gaping beneath. A moment of forgetfulness, a slip, a mere nothing, might bring her within reach of a pair of strong nippers which would not let slip the chance of a pitiless vengeance. In certain specially difficult cases, if not always, the movement of these redoubtable pincers must be stopped, and the harpoon-like tarsi prevented from adding to the difficulties of transport.

What will the Sphex do to obtain this result? Man, and even a learned man, would hesitate, bewilder himself with vain attempts, and perhaps despair of success. Let him come and take a lesson

from the Sphex, who, without having learned, without ever seeing any one else at work, is thoroughly up in her profession of operator. She knows that under her victim's skull lies a circlet of nerve-knots, somewhat analogous to the brain of higher animals. She knows too that this chief nerve centre directs the action of the mouth-parts, and, moreover, is the seat of will, without whose command no muscle acts; finally, she is aware that if this kind of brain be injured, all resistance will cease, the insect no longer possessing will-power. As for the method of operation, it is the easiest thing possible for her, and when we have studied at her school we may try in our turn. The sting is no longer employed; in her wisdom the Spex decides compression to be preferable to the poisoned sting. Let us bow to her decision, for we shall presently see how prudent it is to be convinced of our ignorance compared with the animal's knowledge. Lest by re-writing my account I fail to do justice to the sublime talent of this masterly operation, I transcribe my notes written on the spot directly after witnessing the exciting spectacle.

The Sphex, finding that her prey resists too much, hooking itself here and there to blades of grass, pauses to perform the singular operation about to be described—a kind of *coup de grâce*. The Hymenopteron, still astride her victim, makes the articulation in the upper part of the neck, at the nape, to open wide. Then she seizes the neck with her mandibles, groping as far forward as possible under the skull, but making no outward wound, grasps and chews repeatedly the nerve-centres of the head. This renders her victim quite motionless, and incapable

of the least resistance, whereas previously the feet, though unable to move in the manner necessary for walking, vigorously resisted being dragged along. This is the fact in all its eloquence. While leaving intact the thin, supple membrane of the neck, the insect finds a way into the skull with the point of its mandibles, and bruises the brain. There is neither effusion of blood nor wound, but merely external compression. Of course I kept the paralysed ephippiger under inspection in order to watch the consequences of the operation at my leisure, and equally of course I hastened to repeat on living specimens what the Sphex had taught me. I will now compare my results with hers.

Two ephippigers, whose cervical ganglia I compressed with pincers, fell quickly into a state like that of her victims, only they sounded their harsh cymbals if irritated by the point of a needle, and their feet made some irregular languid movements. The difference in the results obtained doubtless arises from the fact that my victim had not been previously stung in the thoracic ganglia, as those had been which the Sphex had struck in the breast. Allowing for this important point, it will be seen that I made no bad pupil, and imitated my teacher in physiology, the Sphex, not ill. I own that it was not without a certain satisfaction that I found I had done almost as well as the insect does.

As well! What have I just said? Wait a little, and it will be seen that I had to attend the Sphex's school for many another day. For my two ephippigers speedily died—died outright, and after three or four days I had only decaying bodies under my eyes.

But the ephippiger of the Sphex? Need I say that ten days after the operation this was perfectly fresh, as it has to be for the larva whose destined prey it is. Yet more, a few hours after the operation under the skull, there reappeared as if nothing had happened movements of an irregular kind in feet, antennæ, palpi, ovipositor, and mandibles—in short, the creature was again in the same state as before the Sphex bit its brain. And the movements went on, only feebler each day. The Sphex had only benumbed her victim for a period amply sufficient to enable her to get it home without resistance, while I, who thought myself her rival, was but a clumsy, barbarous butcher, and killed mine. She, with her inimitable dexterity, compressed the brain scientifically to cause a lethargy of a few hours; I, brutal through ignorance, perhaps crushed this delicate organ, primal source of life, with my pincers. If anything could prevent my blushing at my defeat, it would be that few if any could rival the Sphex in skill.

Ah! now I comprehend why she did not use her sting to injure the ganglia of the neck. A drop of poison instilled here, at the centre of vital force, would annihilate all nerve power, and death would soon follow. But the Sphex does not at all desire death. Dead food by no means suits the larvæ, and still less a body smelling of decay. All that is needed is lethargy, a passing torpor, hindering resistance while the victim is carted along—resistance difficult to overcome and dangerous to the Sphex. This torpor is obtained by the proceeding known in laboratories of experimental science as compression

of the brain. The Sphex acts like a Flourens who, baring an animal's brain and pressing on the cerebrum, abolishes at once sensibility, will, intelligence, and motion. The pressure ceases and all reappears. So reappear the remains of life in the ephippiger as the lethargic effects of a skilful pressure go off. The ganglia of the skull, squeezed by the mandibles, but without mortal contusions, gradually recover activity, and put an end to the general torpor. It is alarmingly scientific!

Fortune has her entomological caprices; you run after her and do not come up with her; you forget her, and lo, here she is tapping at your door! How many useless excursions, how many fruitless plans, you made to try to see Sphex occitanica sacrifice her victim! Twenty years go by; these pages are already in the printer's hands, when, in the first days of this month (August 8, 1878), my son Emile darts into my study. "Quick! quick!" he cries, "a Sphex is dragging along her prey under the plane trees, before the door of the court!" Emile, initiated into the affair by what I had told him, and, better still, by like facts seen in our out-of-door life, was quite right. I hurried away, and saw a splendid S. occitanica dragging a paralysed ephippiger by the antennæ. She moved toward the poultry yard, seemingly desirous of scaling the wall, to make her burrow under some roof tile. Some years before I had seen a similar Sphex accomplish the ascent with her game, and choose her domicile under the arch of an ill-joined tile. Perhaps this new one was descended from her whose difficult ascent I have chronicled. A like feat is probably about to be

THE SPHEX OF LANGUEDOC DRAGGING TO ITS BURROW AN EPHIPPIGER OF THE VINE [*To face p.* 156.

repeated, and this time before numerous witnesses, for all the household working under the shade of the plane trees formed a circle round the Sphex. They wonder at the audacious tameness of the insect, noways disturbed by the gallery of interested spectators. All are struck by her proud and robust bearing, as, with raised head and the victim's antennæ well grasped by her mandibles, she drags after her the enormous burden. I alone among the spectators feel some regret. "Ah, had I but some live ephippigers!" I could not help saying, without the least hope of seeing my wish realised. "Live ephippigers!" replied Emile; "why, I have some quite fresh, caught this morning." Four steps at a time he flew upstairs to his little study, where barricades of dictionaries enclosed a park wherein was brought up a fine caterpillar of Sphinx euphorbiæ. He brought back three ephippigers as good as heart could wish—two females and one male. How came these insects at hand just at the right moment for an experiment vainly tried twenty years before? This is another story. A southern shrike had nested on one of the tall plane trees in the avenue. Some days before the Mistral, the rude wind of our parts, had blown so violently that branches bent as well as reeds, and the nest overturned by the undulations of its branch let fall the four nestlings it contained. The next day I found the brood on the ground—three killed by the fall, the fourth still alive. The survivor was entrusted to Emile, who thrice a day went cricket-hunting on the turf in the neighbourhood to feed his charge. But crickets are not very large, while the nestling's appetite was. Something

else was preferred—ephippigers, collected from time to time on the dry stalks and prickly leaves of the Eryngium. The three insects brought me by Emile came from the shrike's larder. My pity for the fallen nestlings had brought me this unhoped-for good luck.

Having made the circle of spectators draw back and leave free passage for the Sphex, I took away her prey with my pincers, giving her immediately in exchange one of my ephippigers with an ovipositor like that of the one abstracted. Stamping was the only sign of impatience shown by the bereaved Hymenopteron. She ran at the new prey, too corpulent to try to avoid pursuit, seized it with her mandibles by the saddle-shaped corslet, got astride, and curving her abdomen, passed its end under the ephippiger's thorax. There doubtless the stings are given, but the difficulty of observation prevents me from telling how many. The ephippiger—gentle victim—lets itself be operated on unresistingly, like the dull sheep of our slaughter-houses. The Sphex takes her time and manœuvres her lancet with a deliberation favourable to the observer; but the prey touches the ground with the whole lower part of its body, and what happens there cannot be seen. As for interfering and lifting the ephippiger a little so as to see better, it is not to be thought of; the murderess would sheath her weapon and retire. The next act is easy to observe. After having stabbed the thorax, the end of the abdomen appears under the neck, which she forces widely open by pressing the nape. Here the sting enters with marked persistence, as if more effective than elsewhere. One

might suppose that the nerve centre struck was the lower part of the œsophagean collar, but the persistence of movement in the mouthpieces, mandibles, jaws, and palpi, animated by this source of nerve power, shows that this is not so. Through the neck the Sphex simply reaches the thoracic ganglia, or at least the first, more easily attainable through the thin skin of the neck than through the integuments of the chest.

All is over. Without one convulsion or sign of pain the ephippiger is rendered henceforward an inert mass. For the second time I deprived the Sphex of the subject operated on, replacing it by the second female at my disposal. The same manœuvres were followed by the same result. Three times, almost without a pause, the Sphex repeated her skilled surgery, first on her own capture, then on those exchanged by me. Will she do so a fourth time on the male which I still have? It is doubtful, not that she is weary, but because the game does not suit her. I have never seen a Sphex with any but female prey, which, filled as they are with eggs, are the favourite food of the larvæ. My suspicion was well founded. Deprived of her third capture, she obstinately refused the male which I offered her. She ran hither and thither with hurried steps, seeking her lost prey. Three or four times she approached the ephippiger, walked round it, cast a disdainful glance at it, and finally flew away. This was not what her larvæ wanted. Experiment reiterated it after twenty years' interval.

The three females, two stabbed under my eyes, remained mine. All the feet were quite paralysed,

Whether in its natural position or on its back or side, the creature retains whichever is given it. Constant oscillations of the antennæ, and, at intervals, some pulsations of the stomach and movements of the mouthpieces, are the only sign of life. Motion is destroyed but not feeling, for at the least prick where the skin is thin, the whole body shudders faintly. Perhaps one day physiology will discover in these victims a subject for fine studies on the functions of the nervous system. The Hymenopteron's sting, incomparably skilful in reaching a given point and inflicting a wound to affect it alone, will replace, with immense advantage, the brutal scalpel of the experimenter, which disembowels where it should lightly touch. Meanwhile, here are the results obtained from the three victims, but from another point of view.

Only movement of the feet being destroyed, there being no injury save that to the nerve centres, the source of motion, the creature perishes, not from its wound, but from inanition. The experiment was tried thus:

Two uninjured ephippigers found in the fields were imprisoned without food, one in the dark, the other in the light. In four days the latter died of hunger, in five the former. This difference of a day is easily explained. In the light the creature is more eager to recover liberty, and as every movement of the animal machine causes a corresponding expenditure of energy, greater activity used up sooner the reserves of the organisation. With light, more agitation and shorter life; in darkness, less movement and longer life; both insects fasted

equally. One of the three stabbed was kept in the dark and foodless. In this case there was not only darkness and want of food, but the serious wounds inflicted by the Sphex, and yet for seventeen days it perpetually moved its antennæ. As long as this kind of pendulum oscillates, the clock of life has not stopped. On the eighteenth day the creature ceased to wave its antennæ and died. Thus the seriously wounded insect lived in the same conditions as the uninjured one four times as long. What seems as if it should be a cause of death is really the cause of life.

However paradoxical it may at first appear, this result is perfectly simple. Intact, the creature agitates and spends itself; paralysed, it makes only those feeble, internal movements, inseparable from all organised life, and the waste of substance is in proportion to the amount of action employed. In the first case the animal machine works and spends itself; in the second it is at rest and saves itself up. Nourishment no longer repairing loss, the insect in motion spends in four days its food reserves and dies; the motionless one does not spend them, and lives eighteen. Physiology tells us that life is continual destruction, and the Sphex's victims are a most elegant demonstration of this fact.

One more remark. Fresh food is absolutely necessary to larvæ of the Hymenopteron. If the prey were stored intact, in four or five days it would be a dead body, given up to decay, and the newly hatched grubs would find no food but a corrupted mass. Touched by the sting it can live two or three weeks—a period more than sufficient for the

egg to hatch and the grub to develop. The paralysis has thus a double result—immobility, so as not to endanger the life of the delicate larvæ, and long preservation of the flesh to assure wholesome nourishment for them. Even when enlightened by science human logic could find nothing better.

My two other ephippigers, stung by the Sphex, were kept in darkness with food. To feed inert creatures, differing only from dead bodies by the perpetual oscillation of their long antennæ, seems at first an impossibility; however, the play of the mouth organs gave me some hope, and I made the attempt. My success surpassed my expectations. There was no question, of course, of offering them a lettuce leaf or any other green thing on which they might have browsed in their normal condition; they were feeble invalids, to be nourished with a feeding-cup, so to say, and broth. I used sugar and water.

The insect being laid on its back, I put a drop of sugared liquid on its mouth with a straw. Instantly the palpi stirred, mandibles and jaws moved; the drop was consumed with evident satisfaction, especially if the fast had been somewhat prolonged. I renewed the dose till it was refused. The repast took place once or twice a day at irregular intervals, as I could not devote myself very much to a hospital of this kind.

Well, with this meagre diet one of the ephippigers lived twenty-one days. This was little longer than the life of the one which I allowed to die of inanition. It is true that twice the insect had had a bad fall, having dropped from the experiment table to the floor through some awkwardness of mine.

The bruises consequent may have hastened its end. As for the other, exempt from accidents, it lived six weeks. As the nourishment offered, sugar and water, could not indefinitely replace the natural food, it is very probable that it would have lived longer still had its customary diet been available. Thus the point which I had in view is demonstrated: victims pierced by the sting of the Hymenopteron die from inanition and not of their wound.

XII

THE IGNORANCE OF INSTINCT

THE Sphex has just shown us with what infallible, transcendent art she acts, guided by the unconscious inspiration of instinct: she will now show how poor she is in resources, how limited in intelligence, and even illogical in cases somewhat out of her usual line. By a strange contradiction, characteristic of the instinctive faculties, with deep science is associated ignorance not less deep. Nothing is impossible to instinct, however great be the difficulty. In constructing her hexagonal cells with their floor of three lozenge-shaped pieces, the bee resolves, with absolute precision, the arduous problems of maximum and minimum, to solve which man would need a powerful, mathematical mind. Hymenoptera, whose larvæ live on prey, have methods in their murderous art hardly equalled by those of a man versed in the most delicate mysteries of anatomy and physiology. Nothing is difficult to instinct so long as the action moves in the unchanging groove allotted to the animal, but, again, nothing is easy to instinct if the action deviates from it. The very insect which amazes us and alarms us by its high intelligence will, a moment later, astonish

us by its stupidity before some fact extremely simple, but strange to its usual habits. The Sphex will offer an example.

Let us follow her dragging home an ephippiger. If fortune favour us, we may be present at a little scene which I will describe. On entering the shelter under a rock where the burrow is made, the Sphex finds, perched on a blade of grass, a carnivorous insect which, under a most sanctimonious aspect, hides the morals of a cannibal. The danger threatened by this bandit in ambush on her path must be known to the Sphex, for she leaves her game and runs bravely at the Mantis to administer some sharp blows and dislodge, or at all events, alarm and inspire it with respect. It does not move, but closes its deadly weapons—the two terrible saws of the arm and forearm. The Sphex returns to her prey, harnesses herself to the antennæ, and passes audaciously under the blade of grass where the Mantis sits. From the direction of her head one can see that she is on her guard, and is holding the enemy motionless under her threatening eyes. Such courage is duly rewarded; the prey is stored without further misadventure.

A word more of the Praying Mantis, the *Prégo Diéou* as it is called in Provence, *i.e.* the Pray-to-God. And, indeed, its long, pale green wings, like ample veils, its head upraised to heaven, its arms folded and crossed on its breast, give it a false resemblance to a nun in ecstatic devotion. All the same, it is a ferocious creature, bent on carnage. Although not especially favourite hunting-grounds, the workshops of various burrowing Hymenoptera are often visited by

it. Posted on some bush near the burrows, it waits until chance brings some Sphex returning home within reach, thus achieving a double capture, catching together Sphex and prey. Its patience is long tried; the Sphex is suspicious and on her guard, but from time to time a rash one lets herself be caught. By a sudden rustle of half-spread wings, as by a convulsive movement, the Mantis terrifies the approaching Sphex, which hesitates for a moment, and then with the suddenness of a spring the toothed forearm folds back on an arm also toothed, and the insect is seized between the blades of the double saw, as though the jaws of a wolf trap were closing on the beast as it takes the bait. Then, without unclosing the cruel machine, the Mantis gnaws little mouthfuls of its victim. Such are the ecstasies, the prayers, and the mystic meditations of the *Prégo Diéou*.

Among the scenes of carnage which the Mantis has left in my memory, let me describe the following. It passes before a working-place of Philanthus apivorus. These miners nourish their larvæ with hive-bees, which they seize on flowers while collecting pollen and honey. If the Philanthus feels that the bee is full of honey, it does not fail to squeeze it before storing it, either on the way, or at the entrance of the hole, to make it disgorge the delicious liquid; this it drinks by licking the tongue of the unfortunate bee, which, dying, extends it at full length. This profanation of a dying creature, squeezed by its murderer to empty its body and enjoy the contents, has something so hideous that I should call it a crime if a Philanthus could be held responsible. In

THE SPHEX OF LANGUEDOC AND ITS ENEMY, THE PRAYING MANTIS [*To face p.* 166.

the midst of this horrible banquet I have seen both murderer and prey seized by the Mantis; the robber was plundered by a second robber. Horrible to relate, while the Mantis held it transpierced by the points of the double saw, and was already gnawing the under parts, the Philanthus went on licking the honey, unable to abandon the delicious food even in the throes of death. Let us cast a veil over these horrors.

We return to the Sphex, with whose burrow we must make acquaintance before going further. It is made of fine sand, or rather in the fine dust at the bottom of a natural shelter. Its passage is very short—an inch or two without a turn, leading into a single spacious oval chamber, and all is a rude, hastily made den, rather than a dwelling hollowed with art and leisure. I have already said that the captured prey, left for a brief moment or two where it was hunted, is the cause of the simplicity of this abode and of there being but one chamber or cell to each hollow. For who can say whither the chances of the day's hunt may lead? The dwelling must be near the heavy prey, and to-day's abode, too far off to admit of carrying the second ephippiger there, cannot be used to-morrow. Thus each time prey is caught there must be new digging out—a new burrow with its one cell, now here, now there. Now let us try some experiments to see how the insect behaves amid circumstances new to it.

First experiment.—A Sphex, dragging her prey, is at a few inches from her burrow. Without disturbing her I cut the antennæ of the ephippiger, which we already know serve as harness. Having

recovered from her astonishment at the sudden lightening of her load, the Sphex returns and unhesitatingly seizes the base of the antennæ, the short stumps not cut off. Very short they are—hardly a millimetre long; no matter, they suffice for the Sphex, who grips what remains of her ropes and drags anew. With many precautions not to hurt her, I cut off the two stumps, now level with the skull. Finding nothing to seize at the parts familiar to her, she takes hold on one side of one of the long palpi of her victim, and drags it, not at all put out by this modification in her style of harnessing herself. I leave her alone. The prey is got home and placed with its head to the mouth of the burrow. The Sphex enters to make a short inspection of the interior before proceeding to store provisions. Her tactics recall those of S. flavipennis in like circumstances. I profit by this brief moment to take the abandoned prey, deprive it of all its palpi, and place it a little farther off—a pace from the burrow. The Sphex reappears and goes straight to her game, which she saw from her threshold. She seeks above the head, she seeks below, on one side, and finds nothing to seize. A desperate attempt is made; opening wide her mandibles she tries to grasp the ephippiger by the head, but her pincers cannot surround anything so large, and slip off the round, polished skull. She tries several times in vain; at length, convinced of the futility of her efforts, draws back, and seems to renounce further attempts. She appears discouraged—at least she smooths her wings with her hind feet, while with her front tarsi, first passing them through her mouth, she washes her

eyes, a sign among Hymenoptera, as I believe, that they give a thing up.

Yet there were points by which the ephippiger might be seized and dragged as easily as by the antennæ and palpi. There are the six feet, there is the ovipositor—all organs slender enough to be thoroughly grasped and used as traction ropes. I own that the easiest way of getting the prey into the storehouse is to introduce it head first by the antennæ; yet, drawn by one foot, especially a front one, it would enter almost as easily, for the orifice is wide and the passage short, even if there be one. How came it then that the Sphex never once tried to seize one of the six tarsi or the point of the ovipositor, while she did make the impossible, absurd attempt to grip with mandibles far too short the huge head of her prey? Perhaps the idea did not occur to her. Let us try to suggest it. I place under her mandibles first a foot, then the end of the abdominal sabre. She refuses obstinately to bite; my repeated solicitations come to nothing. A very odd kind of hunter this to be so embarrassed by her game and unable to think of seizing it by a foot if it cannot be taken by the horns! Perhaps my presence and all these unusual events may have troubled her faculties; let us leave her to herself, with her burrow and ephippiger, and give her time to consider and to imagine in the calm of solitude some means of managing the business. I walked away and returned in a couple of hours to find the Sphex gone, the burrow open, and the ephippiger where I had laid it. The conclusion is that the Sphex tried nothing, but departed, abandoning home,

game—everything, when to utilise them all that was needed would have been to take the prey by one foot. Thus this rival of Flourens, who just now startled us by her science when pressing the brain to induce lethargy, is invariably dull when the least unusual event occurs. The Sphex, which knows so well how to reach the thoracic ganglia of a victim with her sting, and those of the brain with her mandibles, and which makes such a judicious difference between a poisoned sting that would destroy the vital influence of the nerves, and compression causing only momentary torpor, cannot seize her prey in a new way. To understand that a foot may be taken instead of the antennæ is impossible; nothing will do but the antennæ or another filament of the head or one of the palpi. For want of these ropes her whole race would perish, unable to surmount this trifling difficulty.

Second experiment.—The Sphex is busy closing her burrow where the prey is stored and the egg laid. With her fore tarsi she sweeps backward before her door, and launches from the entrance a spurt of dust, which passes beneath her, and springs up behind in a parabolic curve as continuous as if it were a slender stream of some liquid, so rapidly does she sweep. From time to time she chooses some sand grains with her mandibles, strengthening materials inserted singly in the dusty mass. To consolidate this she beats it with her head, and heaps it with her mandibles. Walled up by this masonry, the entrance rapidly disappears. In the midst of the work I intervene. Having put the Sphex aside I clear out the short gallery carefully with the blade

of a knife, take away the materials which block it, and entirely restore the communication of the cell with the outer air. Then, without injuring the edifice, I draw the ephippiger out of the cell where it is lying with its head to the far end, and its ovipositor to the entrance. The egg is as usual on its breast, near the base of one of the hind legs—a proof that the Sphex had given her last touch to the burrow, and would never return. These dispositions made, and the ephippiger placed safely in a box, I gave up my place to the Sphex, who had been watching while her domicile was rifled. Finding the entrance open, she entered and remained some moments, then came forth and took up her work where I interrupted it, beginning to stop the entrance conscientiously, sweeping the dust backward, and transporting sand grains to build them with minute care, as if doing a useful work. The orifice being again thoroughly blocked, she brushed herself, seemed to give a glance of satisfaction at her work, and finally flew off.

Yet she must have known that the burrow was empty, since she had gone inside, and made prolonged stay, but yet after this visit to the plundered dwelling, she set to work to close it with as much care as if nothing had happened. Did she propose to turn it later to account, returning with a fresh prey, and laying a new egg? In that case the burrow was closed to defend it from indiscreet visitors while the Sphex was away. Or it was a measure of prudence against other miners who might covet a ready-made chamber, or a wise precaution against internal wear and tear, and, in fact,

some predatory Hymenoptera are careful when obliged to suspend work to defend the mouth of their burrow by closing it up temporarily. I have seen certain Ammophilæ, whose burrow is a vertical well, close the entrance with a little flat stone when the insect goes a-hunting, or stops mining when the hour to leave off work comes at sunset. But in that case the stoppage is slight—a mere slab set on the top of the well. It takes but a moment when the insect comes to displace the little flat stone, and the door is open. But what we have just seen the Sphex construct is a solid barrier—strong masonry, where layers of alternate dust and gravel occupy the whole passage. It is definitive, and no temporary work, as is sufficiently shown by the careful way in which it is constructed. Besides, as I think I have already proved, it is very doubtful, considering the manner in which she acted, whether the Sphex would return to use the dwelling which she had prepared. A new ephippiger will be caught elsewhere, and elsewhere too will the storehouse destined for it be hollowed. As, however, these are but conclusions drawn by reasoning, let us consult experiment, more conclusive here than logic. I let nearly a week pass in order to allow the Sphex to return to the burrow so methodically closed, and use it if she liked for her nest-laying. Events answered to the logical deduction; the burrow was just as I had left it, well closed, but without food, egg, or larva. The demonstration was decisive; the Sphex had not returned.

Thus we see the plundered Sphex go into her house, pay a leisurely visit to the empty chamber,

and the next moment behave as if she had not perceived the absence of the big prey which a little while before had encumbered the cell. Did she not realise the absence of food and egg? Was she really so dull—she, so clear-sighted when playing the murderer—that the cell was empty? I dare not accuse her of such stupidity. She did perceive it. But why then that other piece of stupidity which made her close, and very conscientiously too, an empty chamber which she did not mean to store? It was useless—downright absurd—to do this, and yet she worked with as much zeal as if the future of the larva depended on it. The various instinctive actions of insects are then necessarily connected; since one thing has been done, such another must inevitably follow to complete the first, or prepare the way for the next, and the two acts are so necessarily linked that the first must cause the second, even when by some chance this last has become not only superfluous, but sometimes contrary to the creature's interest. What object could there be in stopping a burrow now useless, since it no longer contained prey and egg, and which will remain useless, since the Sphex will not return to it? One can only explain this irrational proceeding by regarding it as the necessary consequence of preceding actions. In the normal state of things the Sphex hunts her prey, lays an egg, and closes the hole. The prey has been caught, the egg laid, and now comes the closing of the burrow, and the insect closes it without reflecting at all, or guessing the fruitlessness of her labour.

Third experiment.—To know all and nothing,

according as the conditions are normal or otherwise, is the strange antithesis presented by the insect. Other examples drawn from the Sphegidæ will confirm us in this proposition. Sphex albisecta attacks middle-sized Acridians, the various species scattered in the neighbourhood of her burrow all furnishing a tribute. From the abundance of these Acrididæ the chase is carried on near at hand. When the vertical well-like burrow is ready, the Sphex merely flies over the ground near, and espies an Acridian feeding in the sunshine. To pounce and sting while it struggles is done in a moment. After some fluttering of the wings, which unfold like carmine or azure fans, some moving of feet up and down, the victim becomes motionless. Next it must be got home by the Sphex on foot. She performs this toilsome operation as do her kindred, dragging her game between her feet, and holding one of the antennæ in her mandibles. If a grass thicket has to be traversed, she hops and flutters from blade to blade, keeping firm hold of her prey. When within a few feet of her dwelling she executes the same manœuvre as does S. occitanica, but without attaching the same importance to it, for sometimes she neglects it. The game is left on the road, and though no apparent danger threatens the dwelling, she hurries toward its mouth, and puts in her head repeatedly, or even partly enters, then returns to the Acridian, brings it nearer, and again leaves it to revisit her burrow, and so on several times, always with eager haste.

These repeated visits have sometimes annoying results. The victim, rashly abandoned on a slope,

rolls to the bottom, and when the Sphex returns and does not find it where she left it, she must hunt for it, sometimes in vain. If found, there will be a difficult climb, which, however, does not prevent her leaving it once more on the perilous slope. The first of these repeated visits to her cell is easily explained. Before bringing her heavy load she is anxious to make sure that the entrance is clear, and that nothing will hinder her carrying in the prey. But what is the use of her other visits, repeated so speedily one after another? Are the Sphex's ideas so unstable that she forgets the one just made, and hurries back a moment later, only to forget that she has done so, and so on? It would indeed be a slippery memory where impressions vanished as soon as made. Let us leave this too obscure question.

At length the game is brought to the edge of the well, its antennæ hanging into the mouth, and there is an exact repetition of the method used by S. flavipennis, and, though in less striking conditions, by S. occitanica. She enters alone, reappears at the entrance, seizes the antennæ, and drags in the Acridian. While she was within I have pushed the prey rather farther off, and have always obtained precisely the same result as in the case of the huntress of crickets. In both Sphegidæ there was the same persistence in plunging into their burrows before dragging down their prey. We must recollect that S. flavipennis does not always allow herself to be duped by my trick of withdrawing the insect. There are elect tribes among them,—strong-minded families,—who after a

while find out the tricks of the experimenter, and know how to baffle them. But these revolutionaries capable of progress are the few; the rest, rigid conservatives in manners and customs, are the majority, the crowd. I cannot say whether the hunters of Acrididæ show more or less cunning in different districts.

But the most remarkable thing, and the one to which I want specially to come, is this. After withdrawing the prey of S. albisecta several times from the mouth of the hole, and obliging her to fetch it back, I profited by her descent to the bottom of her den to seize and put the prey where she could not find it. She came up, sought about for a long time, and, when quite convinced that it was not to be found, went down again. A few moments later she reappeared. Was it to return to the chase? Not the least in the world; she began to close the hole, and with no temporary cover, such as a small flat stone to mark the orifice, but with a solid mass of carefully collected dust and gravel swept into the passage until it was quite filled. S. albisecta only makes a single cell at the bottom of her well, and puts in but one victim. This one specimen had been caught and dragged to the edge of the hole, and if it was not stored, that was my fault, not her's. The Sphex worked by an inflexible rule, and according to that rule she completed the work by stopping up the hole even if empty. Here we have an exact repetition of the useless labour of S. occitanica whose dwelling I rifled.

Fourth experiment.—It is almost impossible to

be certain whether S. flavipennis, which makes several calls at the bottom of the same passage, and heaps several grasshoppers in each, commits the same irrational mistakes when accidentally disturbed. A cell may be closed, although empty or imperfectly stored, and yet the Sphex will return to the same burrow to make others. Yet I have reason to believe that this Sphex is subject to the same aberrations as her two relations. The facts on which I base my belief are these. When the work is completed, there are generally four grasshoppers in each cell, but it is not uncommon to find three or only two. Four appears to me the usual number—first, because it is the most frequent, and secondly, when I have brought up young larvæ dug up when eating their first grasshopper, I found that all, even those only provided with two or three, easily finished those offered, up to four, but after that they hardly touched the fifth ration. If four grasshoppers are required by the larva to develop fully, why is it sometimes only provided with three or even only two? Why this immense difference in the amount of food? It cannot be from any difference in the joints served up, since all are unmistakably of the same size, but must come from losing prey on the road. In fact, one finds at the foot of the slopes whose upper parts are occupied by Sphegidæ, grasshoppers killed, and then lost down the incline, when, for some reason or other, the Sphex has momentarily left them. These grasshoppers become the prey of ants and flies, and the Sphex who finds them takes good care not to pick them up, as they would take enemies into the burrow.

These facts seem to demonstrate that if S. flavipennis can compute exactly how many victims to catch, she cannot attain to counting how many reach their destination, as if the creature had no other guide as to number than an irresistible impulse leading her to seek game a fixed number of times. When this number of journeys has been made,—when the Sphex has done all that is possible to store the captured prey,—her work is done, and the cell is closed, whether completely provisioned or not. Nature has endowed her with only those faculties called for under ordinary circumstances by the interests of the larva, and these blind faculties, unmodified by experience, being sufficient for the preservation of the race, the animal cannot go farther.

I end then as I began: instinct knows everything in the unchanging paths laid out for it; beyond them it is entirely ignorant. The sublime inspirations of science, the astonishing inconsistencies of stupidity, are both its portion, according as the creature acts under normal conditions or under accidental ones.

XIII

AN ASCENT OF MONT VENTOUX

By its isolation, which leaves it freely exposed on every side to the influence of atmospheric agencies, and from the height which makes it the culminating point of France on this side of the frontiers of Alps or Pyrenees, the bare Provençal mountain, Mont Ventoux, lends itself remarkably to studies of plant species according to climate. At the base flourish the tender olive and that crowd of small semi-woody plants whose aromatic scent requires the sun of southern regions. On the summit, where snow lies at least half the year, the ground is covered with a northern flora, partly borrowed from the arctic regions. Half a day's journey in a vertical line brings before one's eyes a succession of the chief vegetable types met with in the same meridian in long travels from south to north. When you start your feet crush the perfumed thyme which forms a continuous carpet on the lower slopes; some hours later they tread the dusky cushions of Saxifraga oppositifolia, the first plant seen by a botanist who lands in July on the shores of Spitzbergen. In the hedges below you had gathered the

scarlet blossoms of the pomegranate, which loves an African sky; up above you find a hairy little poppy sheltering its stalks under a covering of small stony fragments, and which opens its large yellow corolla in the icy solitudes of Greenland and the North Cape, just as it does on the highest slopes of Ventoux.

Such contrasts have always a new charm, and twenty-five ascents have not yet brought me satiety. In August 1865 I undertook the twenty-third. We were eight persons—three who came to botanise, five attracted by a mountain expedition and the panorama of the heights. None of those who were not botanists have ever again desired to accompany me. In truth, the expedition is a rough one, and a sunrise does not atone for the fatigue endured.

The best comparison for Mont Ventoux is that of a heap of stones broken up to mend the roads. Raise this heap steeply up to two kilometres, and give it a base in proportion, cast on the white of its limestone the blackness of forests, and you get a clear idea of the general look of the mountain. This heap of débris—sometimes little chips, sometimes huge masses of rock—rises from the plain without preliminary slopes or successive terraces to render ascent less trying by dividing it into stages. The climb begins at once, by rocky paths, the best of which is not as good as a road newly laid with stones, and rising ever rougher and rougher to the summit, a height of 1912 metres. Fresh lawns, glad rivulets, the ample shade of ancient trees—all that gives such a charm to other mountains is here unknown, replaced by an endless bed of calcareous rock broken

into scales which yield under one's feet with a sharp, almost metallic sound. For cascades Mont Ventoux has streams of stones, the sound of which, as they roll downward, replaces the murmur of falling water.

We have reached Bedoin, at the foot of the mountain, arrangements with the guide are completed, the hour of departure is settled, provisions chosen and prepared. Let us try to sleep, for the next night will be a sleepless one on the mountain. But to fall asleep was the difficulty; I have never achieved it, and this is the chief cause of fatigue. I would therefore advise any readers who propose to botanise on Mont Ventoux not to arrive at Bedoin on a Sunday night. They will thus avoid the bustle of a country inn, endless conversations at the top of the speakers' voices, the echo of billiard balls, the clinking of glasses, with the drinking-songs, the nocturnal couplets of passers-by, the bellowing of wind instruments at the neighbouring ball, and the other tribulations inseparable from this holy day of rest and enjoyment. Could one sleep there on other nights? I hope so, but cannot answer for it. I never closed an eye. All night long the rusty spit, labouring for our benefit, groaned under my bedroom; only a thin plank separated me from that diabolical machine.

But already the sky was growing light; a donkey brayed under the windows; the hour had come to rise, and we might as well not have gone to bed at all. Provisions and baggage were loaded, our guide cried "Ja! hi!" and we set off. At the head of the caravan walked Triboulet with his mule and ass—Triboulet, the eldest and chief of the Ventoux guides.

My botanical colleagues scrutinised the vegetation on either side of the road by the early light; the others talked. I followed the party, a barometer slung over my shoulder, a note-book and pencil in my hand.

My barometer, intended for ascertaining the height of the chief botanical stations, soon became a pretext for attacks on the gourd of rum. "Quick, the barometer!" some one would exclaim every time that a remarkable plant was pointed out, and we would all press round the gourd, the barometer coming later. The freshness of the morning and our walk made us appreciate these references to the barometer so much that the level of the tonic liquid lowered even faster than that of the column of mercury. For the future it would be wise to consult Torricelli's tube less frequently.

The temperature grew colder; olive and ilex disappear, next vine and almond, then mulberry, walnut, and white oak; box grows plentiful. We enter on a monotonous region, stretching from the limit of cultivation to the lower edge of the beech woods, where the chief plant is Satureia montana, known here as *pébré d'asé*,—asses' pepper,—from the acrid smell of its small leaves, impregnated with essential oil. Certain little cheeses which form part of our provisions are powdered with this strong spice, and more than one of us casts a famishing glance at the provision bags carried by the mule. Our rough, early expedition had brought an appetite, nay, better still, a devouring hunger, "latrantem stomachum," as Horace wrote. I showed my companions how to still this hunger until we came to

our next halt, pointing out a little sorrel with arrow-shaped leaves, springing among the loose stones, and to set an example I gathered a mouthful. There was a laugh at the notion. I let them laugh, and soon saw one busier than another gathering the precious sorrel.

While chewing the acid leaves we came to the beeches, first large solitary bushes, sweeping the ground, then dwarf trees, close together, then strong trunks, forming a thick dark forest whose soil is a chaos of limestone blocks. Overloaded in winter by snow, beaten all the year round by fierce gusts of the Mistral, many are branchless, twisted into strange shapes, or even prostrate. An hour or more was passed in traversing the wooded zone, which, seen from a distance, looked like a black girdle on the sides of the mountain. Now again the beeches became stunted and scattered; we had reached their upper limit, and, despite the sorrel, all were right glad to come to the spot chosen for our halt and breakfast.

We were at the fountain of La Grave, a slender thread of water caught, as it issues from the ground, in a line of long troughs made of beech trunks, where the mountain shepherds water their flocks. The temperature of the spring was 7 degrees Cent.—a freshness inestimable for us who came up from the sultry heat of the plain. The cloth was spread over a charming carpet of Alpine plants, among which glittered the thyme-leaved Paronychia, whose large thin bracts are like silver scales. The provisions are taken out of their bags, the bottles out of their bed of hay. On this side are the solid dishes, legs

of mutton stuffed with garlic, and piles of bread; there the insipid chickens, good to amuse one's grinders when serious hunger has been appeased. Not far off, in a place of honour, are the Ventoux cheeses sprinkled with asses' pepper, and hard by Arles sausages, whose pink flesh is marbled with squares of bacon and whole pepper. In this corner are green olives still dripping with pickle, and black ones seasoned with oil. In another are melons from Cavaillon, some white, some orange, to suit all tastes, and there a pot of anchovies which make a man drink hard and be tireless on the march, and finally the bottles, cooling in the icy water of a trough. Is nothing forgotten? Yes, we have not mentioned the crown of the feast, raw onions eaten with salt. Our two Parisians, for there are two among us, my fellow botanists, are at first taken somewhat aback by this decidedly bracing bill of fare. They will be the first, a little later, to break forth in its praise. All is ready. Let us to table! Then began one of those homeric meals which make an epoch in one's life. The first mouthfuls have a touch of frenzy. Slices of leg of mutton and bread succeed one another with alarming rapidity. Each of us, without communicating his apprehensions, casts an anxious look on the provender, and says inwardly, "If we go on at this rate, will there be enough for this evening and to-morrow?" However, the craving abated: first we devoured silently, then we ate and talked; fears for the next day abated too; we did justice to him who ordered the bill of fare, and who, foreseeing our voracity, arranged to meet it worthily. Now came the time to appreciate the

provisions as connoisseurs; one praises the olives, stabbing them singly with the point of his knife; another lauds the anchovies as he cuts up the little yellow-ochre fish on his bread; a third speaks enthusiastically of the sausages; and one and all agree in praising the asses'-pepper cheeses, no bigger than the palm of one's hand. Pipes and cigars are lighted, and we lie on our backs in the sun upon the grass.

After an hour's rest it is, "Up! time presses; we must go on!" The guide and luggage were to go westward, along the wood, where there is a mule path. He will wait for us at Jas or Bâtiment, at the upper limit of the beeches, some 1550 metres above the sea. The Jas is a large stone, but capable of sheltering man and beast at night. We were to go upward to the crest which we should follow so as to reach the highest part more easily. After sunset we would go down to the Jas, where the guide would have long arrived; such was the plan proposed and adopted.

We have reached the crest. Southward extend, as far as eye can see, the comparatively easy slopes by which we ascended on the north. The scene is savagely grand, the mountain sometimes perpendicular, sometimes falling in frightfully steep terraces, little less than a precipice of 1500 metres. Throw a stone, and it never stops till, bound after bound, it reaches the valley where one can see the bed of the Toulourenc wind like a ribbon. While my companions moved masses of rock and sent them rolling into the gulf that they might watch the terrible descent, I discovered under a big stone an old

acquaintance in the entomological world—Ammophila hirsuta, which I had always found isolated on banks along roads in the plain, while here, on the top of Mont Ventoux, were several hundreds heaped under the same shelter. I was trying to find the cause of this agglomeration, when the southern breeze, which had already made us anxious in the course of the morning, suddenly brought up a bevy of clouds melting into rain. Before we had noticed them a thick rain-fog wrapped us round, and we could not see a couple of paces before us. Most unluckily one of us, my excellent friend, Th. Delacour, had wandered away looking for Euphorbia saxatilis, one of the botanical curiosities of these heights. Making a speaking trumpet of our hands we all shouted together. No one replied. Our voices were lost in the dense fog and dull sound of the wind in the whirling mass of cloud. Well, since the wanderer cannot hear us we must seek him. In the darkness of the mist it was impossible to see one another two or three paces off, and I alone of the seven knew the locality. In order to leave no one behind, we took each other's hands, I placing myself at the head of the line. For some minutes we played a game of blindman's buff, which led to nothing. Doubtless, on seeing the clouds coming up, Delaçour, well used to Ventoux, had taken advantage of the last gleams of light to hurry to the shelter of Jas. We also must hurry there, for already the rain was running down inside our clothes as well as outside, and our thin white trousers clung like a second skin. A grave difficulty met us: our turnings and goings and comings while we searched

had reduced me to the condition of one whose eyes have been bandaged, and has then been made to pirouette on his heels. I had lost the points of the compass, and no longer knew in the very least which was the southern side. I questioned one and another; opinions were divided and very uncertain. The conclusion was that not one of us could say which was the north and which the south. Never—no, never have I realised the value of the points of the compass as at that moment. All around was the unknown of gray cloudland; below we could just make out the beginning of a slope here or there, but which was the right one? We must make up our minds to descend, trusting to good fortune. If by ill luck we took the northern slope we risked breaking our necks over those precipices the very look of which had so inspired us with fear. Perhaps not one of us would survive. I went through some moments of acute perplexity.

"Let us stay here," said the majority, and wait till the rain stops. "Bad advice," said the others, and I was of the number; "bad advice. The rain may last a long while, and drenched as we are, at the first chill of night we shall freeze on the spot." My worthy friend, Bernard Verlot, come from the Jardin des Plantes at Paris on purpose to ascend Mont Ventoux with me, showed an imperturbable calm, trusting to my prudence to get out of the scrape. I drew him a little on one side so as not to increase the panic of the others, and told him my terrible apprehensions. We held a council of two, and tried to supply the place of the magnetic needle by reasoning. "When the clouds came up,"

said I, "was it not from the south?" "Certainly from the south." "And though the wind was hardly perceptible, the rain slanted slightly from south to north?" "Yes, I noticed that until I got bewildered. Is not that something to guide us? Let us descend on the side whence the rain comes." "I had thought of that, but felt doubtful; the wind was too light to have a clearly defined direction. It might be a revolving current such as are produced on a mountain top surrounded by cloud. Nothing assures me that the first direction has been continuous, and that the current of air does not come from the north." "And in that case?" "Ah! there is the crux! I have an idea! If the wind has not changed, we ought to be wettest on the left side, since the rain came on that side till we lost our bearings. If it has changed we must be pretty equally wet all round. We must feel and decide. Will that do?" "It will." "And if I am mistaken?" "You will not be mistaken."

In two words the matter was explained to our friends. Each felt himself, not outside, which would not have been sufficient, but under his innermost garment, and it was with unspeakable relief that I heard one and all announce the left side much wetter than the right. The wind had not changed. Very good, let us turn toward the rainy quarter. The chain was formed again, Verlot as rearguard, to leave no straggler behind. Before starting, I said once more to my friend, "Shall we risk it?" "Risk it; I follow you," and we plunged into the awful unknown.

Twenty of those strides which one cannot moderate

on a steep slope, and all fear was over. Under our feet was not empty space but the longed-for ground covered with stones which gave way and rolled down behind us in streams. To one and all this rattle denoting *terra firma* was heavenly music. In a few minutes we reached the upper fringe of beeches. Here the gloom was yet deeper than on the mountain top; one had to stoop to the ground to see where one was setting foot. How in the midst of this darkness were we to find the Jas, buried in the depth of the wood? Two plants which always follow man, Good King Henry (Chenopodium Bonus Henricus) and the nettle, served me as a clue. I swept my free hand through the air as I walked, and at each sting I knew there was a nettle and an indication. Verlot, our rearguard, made similar lunges, and supplied the want of sight by the burning stings. Our companions showed no faith in this style of research. They talked of continuing the wild descent and of returning if necessary to Bedoin. More confident in the botanical instinct so keen in himself also, Verlot joined with me in persisting in our search, reassuring the most demoralised, and showing that it was possible by questioning plants with our hands to reach our destination in the darkness. They yielded to our reasoning, and shortly after, from one clump of nettles to another, the party arrived at the Jas.

Delacour was there, as well as the guide with the baggage, sheltered in good time from the rain. A blazing fire and change of garments soon restored our usual cheerfulness. A block of snow, brought from the neighbouring valley, was hung in a bag

before the hearth. A bottle caught the melted water. This would be our fountain for the evening meal. The night was spent on a bed of beech leaves, well crushed by our predecessors, and they were many. Who knows for how many years the mattress had never been renewed? Now it was a hard-beaten mass. The mission of those who could not sleep was to keep up the fire. Hands were not wanting to stir it, for the smoke, with no other exit than a large hole made by the partial falling in of the roof, filled the hut with an atmosphere made to smoke herrings. To get a mouthful of breathable air one must seek it with one's nose nearly level with the ground. There was coughing; there was strong language, and stirring of the fire; but vain was every attempt to sleep. By 2 a.m. we were all on foot to climb the highest cone and behold the sunrise. The rain was over, the sky splendid, auguring a radiant day.

During the ascent some of us felt a kind of sea-sickness, caused partly by fatigue and partly by the rarefaction of the air. The barometer sank 140 millimetres; the air we breathed had lost one-fifth of its density, and was consequently one-fifth poorer in oxygen. By those in good condition this slight modification would pass unnoticed, but, added to the fatigue of the previous day and to want of sleep, it increased our discomfort. We mounted slowly, our legs aching, our breathing difficult. Every twenty steps or so one had to halt. At last the summit was gained. We took refuge in the rustic chapel of St. Croix to take breath and counteract the biting cold by a pull at the gourd, which this

time we emptied. Soon the sun rose. To the farthest limit of the horizon Mont Ventoux projected its triangular shadow, tinted violet from the effect of the diffracted rays. Southward and westward stretched misty plains, where, when the sun rose higher, one would distinguish the Rhône as a silver thread. On the north and east an enormous cloud-bed spreads under our feet like a sea of cotton wool, whence the dark tops of the lower mountains rise as if they were islets of scoriæ, while others with their glaciers shine glorious on the side where the Alps uplift their chain of mountains.

But botany calls, and we must tear ourselves from this magic spectacle. August, the month when we made our ascent, is somewhat late; many plants were out of blossom. Those who really want to be successful should come up here in the first fortnight of July, and, above all, should forestall the arrival of the herds and flocks on these heights. Where a sheep has browsed one finds but poor remains. As yet spared by the grazing flocks, the stony screes on the top of Mont Ventoux are in July literally a bed of flowers. Memory calls up the lovely dew-bathed tufts of Androsace villosa, with white flowers and rosy centres; Viola cenisia, opening great blue corollas on the shattered heaps of limestone; Valeriana saliunca, with perfumed blossoms, but roots that smell like dung; Globularia cordifolia, forming close carpets of a crude green, starred with little blue heads; Alpine forget-me-not, blue as the sky above it; the iberis of Candolle, whose slender stalk bears a dense head of tiny white flowers and creeps down among the loose stones; Saxifraga oppositifolia and

S. muscoides, both making dark thick little cushions, the former with purple blossoms, the latter with white, washed with yellow. When the sun is hotter one sees a splendid butterfly flutter from one blossomed tuft to another, its white wings marked by four patches of vivid rose-carmine encircled with black. It is Parnassius apollo, the graceful dweller in Alpine solitudes, near the eternal snows. Its caterpillar lives on saxifrages. With the Apollo let us end this sketch of the joys which await the naturalist on the top of Mont Ventoux and return to the Ammophila hirsuta, crouching in great numbers under a sheltering stone, when the rain came up and surrounded us.

XIV

THE EMIGRANTS

I HAVE already told how on the top of Mont Ventoux, some 6000 feet above the sea, I had one of those pieces of entomological good luck, which would be fruitful indeed did they but occur often enough to allow of continuous study. Unhappily mine is a unique observation, and I despair of repeating it. Future observers must replace my probabilities by certainties. I can only found conjectures on it.

Under the shelter of a large flat stone I discovered some hundreds of Ammophila hirsuta, heaped in a mass almost as compact as a swarm of bees. As soon as the stone was lifted all the small people began to move about, but without any attempt to take wing. I moved whole handfuls, but not one seemed inclined to leave the heap. Common interests appeared to unite them indissolubly. Not one would go unless all went. With all possible care I examined the flat stone which sheltered them, as well as the soil and immediate neighbourhood, but could discover no explanation of this strange assemblage. Finding nothing better to do, I tried

to count them, and then came the clouds to end my observations and plunge us into that perplexing darkness I have already described. At the first drops of rain I hastened to put back the stone and replace the Ammophila people under shelter. I give myself a good mark, as I hope the reader also will, for having taken the precaution of not leaving the poor things, disturbed by my curiosity, exposed to the downpour.

Ammophila hirsuta is not rare in the plain, but is always found singly on the edge of a road or on sandy slopes, now digging a well, now dragging a heavy prey. It is solitary, like Sphex occitanica, and I was greatly surprised by finding such a number gathered under one stone at the top of Mont Ventoux. Instead of my solitary acquaintance, here was a great assembly. Let us try to educe the probable causes of this agglomeration. By an exception very rare among mining Hymenoptera, Ammophila hirsuta builds in the first days of spring. Toward the end of March, if the season be mild, or at least in the first fortnight of April, when the grasshoppers take their adult form, and painfully cast off their first skin on their thresholds,—when Narcissus poeticus expands its first flowers, and the bunting utters its long-drawn note from the top of the poplars in the meadow,—Ammophila hirsuta sets to work to hollow and provision a home for her larvæ, whereas other species and the predatory Hymenoptera in general undertake this labour only in autumn, during September and October. This very early nidification, preceding by six months the date adopted by the immense majority, at once suggests

AMMOPHILA HIRSUTA ATTACKING A GRUB

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certain considerations. One asks if those found burrowing so early in April are really insects of that year—*i.e.* whether these spring workers completed their metamorphosis and came out of their cocoons during the preceding three months. The general rule is that the Fossor becomes a perfect insect, leaves its burrow, and occupies itself with its larvæ all in one season. It is in June and July that the greater part of the hunting Hymenoptera come from the galleries where they lived as larvæ, and in August, September, and October they follow their occupations as burrowers and hunters.

Does a similar law apply to Ammophila hirsuta? Does the same season witness the final transformation and the labours of the insect? It is very doubtful, for the Hymenoptera, occupied with mining at the end of March, would have to complete their metamorphosis and break forth from the cocoon in winter, or at latest in February. The severity of the climate at that date forbids any such conclusion. It is not when the bitter Mistral howls for a fortnight at a time and freezes the ground, nor when snowstorms follow its icy breath, that the delicate transformations of the nymph state can take place, and the perfect insect venture to quit the shelter of its cocoon. It needs the soft dampness of earth under a summer sun before it can leave its cell.

If I did but know the exact date at which Ammophila hirsuta leaves the cocoon it would greatly help me; but, to my deep regret, I do not. My notes, gathered day by day, show the confusion inseparable from researches that are generally dealing with points that cannot be foreseen, and are

silent on this point, whose importance I fully realise now that I want to arrange my materials in order to write these lines. I find mention of the Ammophila of the sands coming out of the egg on June 5, and A. argentata on the 20th; but I have nothing in my archives regarding the hatching of A. hirsuta. It is a detail left unnoticed through forgetfulness. The dates for the two other species accord with the general law, the perfect insect appearing at the hot time of year. By analogy I fix the same date for the coming forth of A. hirsuta from the cocoon.

Whence, then, come those which one sees at work on their burrows at the end of March and April? We must conclude that they were hatched in the previous year and emerged from their cells at the usual time in June and July, lived through the winter, and began to build as soon as spring came. In a word, they are insects that hibernate. Experience fully confirms this conclusion.

Do but search patiently in a vertical bank of earth or sand well exposed to the sun, especially where generations of the various honey-gathering Hymenoptera have followed one another year after year, riddling the ground with a labyrinth of passages till it looks like a huge sponge, you are nearly sure to see in the heart of winter A. hirsuta either alone or in little parties of three or four, crouched in some warm retreat, waiting inactive till summer shall come. This cheering little meeting, amid the gloom and cold of winter, with the graceful insect which at the first notes of the bunting and the cricket enlivens the grassy paths, is one that I have been able to enjoy at will. If the weather be calm and the sun

has a little power, the chilly insect comes out to bask on its threshold, luxuriating in the hottest beams, or it will venture timidly outside and walk slowly over the spongy bank, brushing its wings. So, too, does the little gray lizard, when the sun begins to warm the old wall which is its home.

But vainly would one seek in winter, even in the most sheltered spots, for a Cerceris, Sphex, Philanthus, Bembex, and other Hymenoptera with carnivorous larvæ. All died after their autumn labours, and their race is only represented by the larvæ benumbed down in their cells. Thus, by a very rare exception, Ammophila hirsuta, hatched in the hot season, passes the following winter in some warm refuge, and this is why it appears so early in the year.

With these data let us try to explain the Ammophila swarm on the crest of Mont Ventoux. What could these numerous Hymenoptera under their sheltering stone have been about? Were they meaning to take up winter quarters there and await under their flat stone, benumbed, the season propitious to their labours? Everything points to the improbability of this. It is not in August, at the time of the greatest heat, that an animal is overcome with winter sleep. Want of their food—the honeyjuice sucked from flowers—cannot be suggested. September showers will soon come, and vegetation, suspended for a while by the heat of the dog days, will assume new vigour and cover the fields with a flowery carpet almost as varied as that of spring. This period—one of enjoyment for most of the Hymenoptera—cannot possibly be one of torpor for A. hirsuta. Again, can one suppose that the heights

of Ventoux, swept by the gusty Mistral, uprooting beech and pine,—summits where the bise whirls about the snow for six months of the year,—crests wrapped for the greater part of the year by cold clouds and mist,—can be adopted as a winter refuge by such a sun-loving insect? One might as well make it hibernate among the ice fields of the North Cape! No, it is not there that A. hirsuta must pass the cold season. The group observed there were making a temporary halt. At the first indication of rain, which, though it escaped us, could not escape the insect so eminently sensitive to the variations of the atmosphere, the wayfarers had taken refuge under a stone, and were waiting for the rain to pass before they resumed their flight. Whence came they? Where were they going?

In this same month of August, and especially in September, there come to the warm olive region flocks of little migratory birds; descending by stages from the lands where they have loved,—fresher, more wooded, more peaceful lands than ours,—where they have brought up their broods. They come almost to a day in an invariable order, as if guided by the dates of an almanac known only to themselves. They sojourn for a while in our plains, where abound the insects which are the chief food of most of them; they visit every clod in our fields where the ploughshare has turned up innumerable worms in the furrows, and feast on them, and with this diet they speedily lay on fat, —a storehouse and reserve to serve as nutrition against toils to come, and thus well provided for the journey they go on southward, to reach winterless

lands where insects are always to be found, such as Spain and Southern Italy, the isles of the Mediterranean and Africa. This is the season for the pleasure of shooting and for succulent roasts of small birds.

The Calandrelle, or Crèou, as Provence calls it, is the first to arrive. As soon as August has begun it may be seen exploring the stony fields, seeking the seeds of the Setaria, an ill weed affecting cultivated ground. At the least alarm it flies off, making a harsh guttural sound sufficiently expressed by its Provençal name. It is soon followed by the whinchat, which preys quietly on small weevils, crickets, and ants in old fields of luzern. With the whinchat begins the long line of small birds suitable for the spit. It is continued in September by the most celebrated of them—the common wheatear, glorified by all who are capable of appreciating its high qualities. Never did the Beccafico of the Roman *gourmet*, immortalised in Martial's epigrams, rival the delicious, perfumed ball of fat the wheat-ear makes when it has grown scandalously obese on an immoderate diet. It consumes every kind of insect voraciously. My archives as a sportsman-naturalist give a list of the contents of its gizzard. All the small people of the fallows are in it,—larvæ and weevils of every kind, crickets, chrysomelides, grasshoppers, cassidides, earwigs, ants, spiders, hundredlegs, snails, wire-worms, and ever so many more. And as a change from this spicy diet there are grapes, blackberries, and cornel-berries. Such is the bill of fare sought incessantly by the wheat-ear as it flutters from clod to clod, the white feathers of its

outspread tail giving it the look of a butterfly on the wing. Heaven only knows to what amount of fat it can attain.

Only one other bird surpasses it in the art of fattening itself, and that is its fellow emigrant,—another voracious devourer of insects,—the bush pipit as it is absurdly styled by those who name birds, while the dullest of our shepherds never hesitate to call it Le Grasset, *i.e.* the fattest of the fat. The name is sufficient to point out its leading characteristic. Never another bird attains such a degree of obesity. A moment arrives when, loaded all over with fat, it becomes like a small pat of butter. The unfortunate bird can hardly flutter from one mulberry tree to another, panting in the thick foliage, half choked with melting fat, a victim to his love of weevil.

October brings the slender gray wagtail, pied ash colour and white, with a large black velvet gorget. The charming bird, running and wagging its tail, follows the ploughman almost under the horses' feet, picking up insects in the newly turned furrow. About the same time comes the lark,—first in little companies thrown out as scouts, then in countless bands which take possession of cornfield and fallow, where abounds their usual food, the seeds of the Setaria. Then on the plain, amid the sparkle of dewdrops and frost crystals suspended to each blade of grass, a mirror shoots intermittent flashes under the morning sun. Then the little owl, driven from shelter by the sportsman, makes its short flight, alights, stands upright with sudden starts and rolling of alarmed eyes, and the lark comes with a dipping

flight, anxious for a close inspection of the bright thing or the odd bird. There it is, some fifteen paces away—its feet hanging, its wings outspread like a *saint-esprit*. The moment has come; aim and fire. I hope that my readers may experience the emotions of this delightful sport.

With the lark, and often in the same flocks, comes the titlark—the *sisi*—another word giving the bird's little call. None rushes more vehemently upon the owl, round and round which it circles and hovers incessantly. This may suffice as a review of the birds which visit us. Most of them make it only a halting-place, staying for a few weeks, attracted by the abundance of food, especially of insects; then, strengthened and plump, off they go. A few take up winter quarters in our plains, where snow is very rare, and there are countless little seeds to be picked up even in the heart of the cold season. The lark which searches wheat fields and fallows is one; another is the titlark, which prefers fields of luzern and meadows.

The skylark, so common in almost every part of France, does not nest in the plains of Vaucluse, where it is replaced by the crested lark—friend of the highway and of the road-mender. But it is not necessary to go far north to find the favourite places for its broods; the next department, the Drôme, is rich in its nests. Very probably, therefore, among the flocks of larks which take possession of our plains for all autumn and winter many come from no farther than the Drôme. They need only migrate into the next department to find plains that know not snow, and a certainty of little seeds.

A like migration to a short distance seems to me to have caused the assemblage of Ammophila on the top of Mont Ventoux. I have proved that this insect spends the winter in the perfect state, sheltering somewhere and awaiting April to build its nest. Like the lark it must take precautions against the cold season; though capable of fasting till flowers return, the chilly thing must find protection against the deadly attacks of the cold. It must flee snowy districts, where the soil is deeply frozen, and, gathering in troops like migrant birds, cross hill and dale to seek a home in old walls and banks warmed by a southern sun. When the cold is gone, all or part of the band will return whence they came. This would explain the assemblage on Mont Ventoux. It was a migrant tribe, which, on its way from the cold land of the Drôme to descend into the warm plains of the olive, had to cross the deep, wide valley of the Toulourenc, and, surprised by the rain, halted on the mountain top. Apparently A. hirsuta has to migrate to escape winter cold. When the small migratory birds set out in flocks, it too must journey from a cold district to a neighbouring one which is warmer. Some valleys crossed, some mountains overpassed, and it finds the climate sought.

I have two other instances of extraordinary insect gatherings at great heights. I have seen the chapel on Mont Ventoux covered with seven-spotted ladybirds, as they are popularly called. These insects clung to the stone of walls and pavement so close together that the rude building looked, at a few paces off, like an object made of coral beads. I should not dare to say how many myriads were

assembled there. Certainly it was not food which had attracted these eaters of Aphidæ to the top of Mont Ventoux, some 6000 feet high. Vegetation is too scanty—never Aphis ventured up there.

Another time, in June, on the tableland of St. Amand, at a height of 734 mètres, I saw a similar gathering, only less numerous. At the most projecting part of the tableland, on the edge of an escarpment of perpendicular rocks, rises a cross with a pedestal of hewn stone. On every side of this pedestal, and on the rocks serving as its base, the very same beetle, the seven-spotted ladybird of Mont Ventoux, was gathered in legions. They were mostly quite still, but wherever the sunbeams struck there was a continuous exchange of place between the newcomers, who wanted to find room, and those resting, who took wing only to return after a short flight. Neither here any more than on the top of Mont Ventoux was there anything to explain the cause of these strange assemblages on arid spots without Aphidæ and noways attractive to Coccinellidæ,—nothing which could suggest the secret of these populous gatherings upon masonry standing at so great an elevation.

Have we here two examples of insect migration? Can there be a general meeting such as swallows hold before the day of their common departure? Were these rendezvous whence the cloud of ladybirds were to seek some district richer in food? It may be so, but it is very extraordinary. The ladybird has never been talked of for her love of travel. She seems a home-loving creature enough when we see her slaying the green-fly on rose trees,

and black-fly on beans, and yet with her short wings she mounts to the top of Ventoux and holds a general assembly where the swallow herself only ascends in her wildest flights. Why these gatherings at such heights? Why this liking for blocks of masonry?

XV

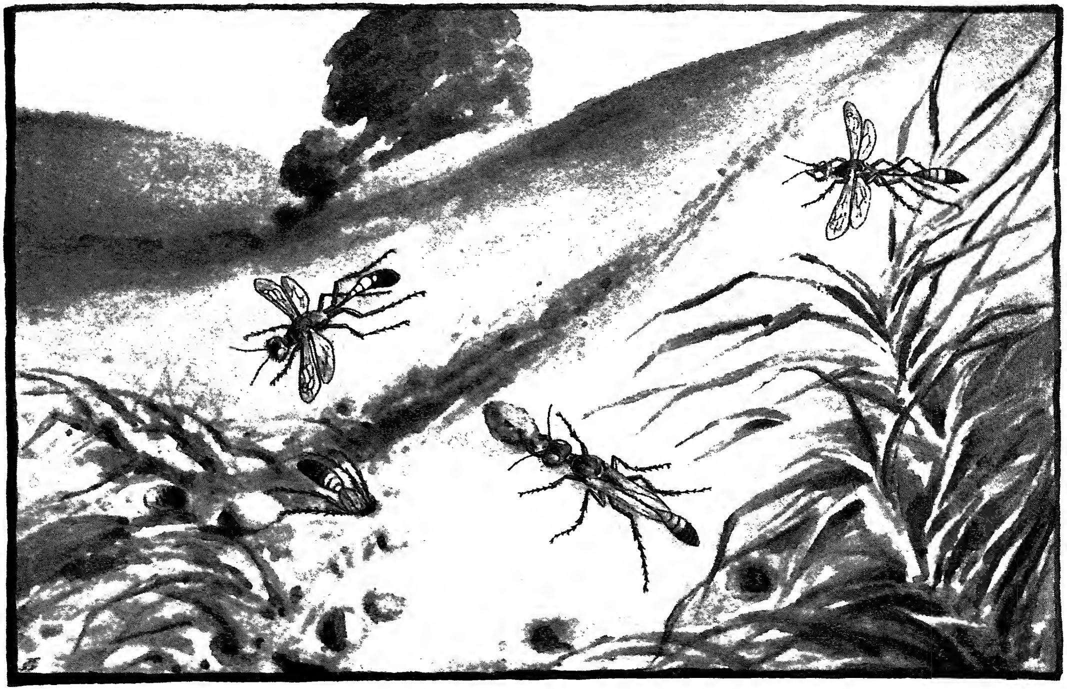
THE AMMOPHILA

A SLENDER waist, a slim shape, an abdomen much compressed at the upper part, and seemingly attached to the body by a mere thread, a black robe with a red scarf on its under parts,—such is the description of these Fossors; like Sphegidæ in form and colouring, but very different in habits. The Sphegidæ hunt Orthoptera, crickets, ephippigers, and grasshoppers, while the Ammophila chases caterpillars. This difference of prey at once suggests new methods in the murderous tactics of instinct.

Did not the name sound pleasant to the ear, I should be inclined to quarrel with Ammophila, which means sand-lover, as being too exclusive and often erroneous. The true lovers of sand—dry, powdery, and slippery sand—are the Bembex, which prey on flies: but the caterpillar-hunters, whose history I am about to tell, have no liking for pure, loose sand, and even avoid it as being too subject to landslips which may be caused by a mere trifle. Their vertical pits, which must remain open until the cell is stored with food and an egg, require more solid

materials if they are not to be blocked prematurely. What they want is a light soil, easy to mine, where the sandy element is cemented by a little clay and lime. The edges of paths—slopes of thin grass exposed to the sun,—such are the places they favour. In spring, from the first days of April, one sees Ammophila hirsuta there; in September and October there are A. sabulosa, A. argentata, and A. holosericea. I will make an abstract of the notes furnished by these four species.

For all four the burrow is a vertical shaft, a kind of well, with at most the dimension of a large goose quill, and about two inches deep. At the bottom is a single cell, formed by a simple widening of the shaft. To sum up, it is a poor dwelling, obtained at small expense, at one sitting, affording no protection if the larva had not four wrappers in its cocoon, like the Sphex. The Ammophila excavates alone, deliberately, with no joyous ardour. As usual, the anterior tarsi do duty as rakes and the mandibles as mining tools. If some grain of sand offer too much resistance, you may hear rising from the bottom of the well a kind of shrill grinding sound, produced by the vibration of the wings and entire body as if to express the insect's struggles. Frequently the Hymenopteron comes up with a load of refuse in its jaws, some bit of gravel which it drops as it flies some little way off, in order not to block up the place. Some appear to merit special attention by their form and size,—at least the Ammophila does not treat them like the rest, for instead of carrying them away on the wing, she goes on foot and drops them near the shaft. They



AMMOPHILA SABULOSA TAKING STONE TO COVER ITS BURROW; A. ARGENTATA MINING

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are choice material—blocks ready prepared to stop up the dwelling by and by.

This outside work is done with a self-contained air and great diligence. High on its legs, its abdomen outstretched at the end of its long petiole, it turns round and moves its whole body at once with the geometrical stiffness of a line revolving on itself. If it has to throw away to a distance the rubbish it decides to be only encumbrances, it does this with little silent flights, often backwards, as if, having come out of the shaft tail first, it thought to save time by not turning round. Species with long-stalked bodies, like A. sabulosa and A. argentata, are those that chiefly display this automaton-like rigidity. Their abdomen, enlarged to a pear-shape at the end of a thread, is very troublesome to manage; a sudden movement might injure the fine stalk, and the insect has to walk with a kind of geometrical precision, and if it flies, it goes backward to avoid tacking too often. On the other hand, A. hirsuta, which has an abdomen with a short petiole, works at its burrow with swift easy movements such as one admires in most of the miners. It can move more freely, not being embarrassed by its abdomen.

The dwelling is hollowed out. Later on, when the sun has passed from the spot where the hole is bored, the Ammophila is sure to visit the little heap of stones set aside during her burrowing, intent to choose some bit which suits her. If she can find nothing that will do she explores round about, and soon discovers what she wants—namely, a small flat stone rather larger than the mouth of her well. She carries it off in her mandibles, and for the time

being closes the shaft with it. Next day, when it is hot again, and when the sun bathes the slopes and favours the chase, she will know perfectly well how to find her home again, secured by the massive door, and she will return with a paralysed caterpillar, seized by the nape of its neck and dragged between its captor's feet; she will lift the stone, which is just like all the others near, and the secret of which is known only to her, will carry down the prey, lay an egg, and then stop the burrow once for all by sweeping into the shaft all the rubbish kept near at hand.

Several times I have seen this temporary closing of the hole by A. sabulosa and A. argentata when the sun grew low and the late hour obliged them to wait until the next day to go out hunting. When they had put the seals on their dwellings I too waited for the morrow to continue my observations, but first I made sure of the spot by taking my bearings and sticking in some bits of wood in order to rediscover the well when closed, and always, unless I came too early, if I let the Hymenopteron profit by full sunshine, I found the burrow stored and closed for good and all.

The fidelity of memory shown here is striking. The insect, belated at its work, puts off completing it until the morrow. It passes neither evening nor night in the new-made abode, but departs after marking the entrance with a small stone. The spot is no more familiar to it than any other, for like Sphex occitanica the Ammophila lodges her family here and there as she may chance to wander. The creature came here by chance, like the soil, and dug

AMMOPHILA HIRSUTA HUNTING FOR CATERPILLARS; AMMOPHILA SABULOSA ON THE WING

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the burrow, and now departs. Whither? Who knows? Perhaps to the flowers near, to lick up by the last gleam of day a drop of sugary liquid at the bottom of their cups, just as a miner after labouring in his dark gallery seeks the consolation of his bottle when evening comes. The Ammophila may be enticed farther and farther by the inviting blossoms. Evening, night, and morning pass, and now she must return to her burrow and complete her task,—return after all her windings and wanderings in the chase that morning, and the flight from flower to flower, and the libations of the previous evening. That a wasp should return to the nest and a bee to the hive does not surprise me; these are permanent abodes, and the ways back are known by long practice, but the Ammophila, who has to return after so long an absence, has no aid from acquaintance with the locality. Her shaft is in a place which she visited yesterday, perhaps for the first time, and must find again to-day when quite beyond her bearings, and, moreover, when she is encumbered by heavy prey. Yet this exploit of topographical memory is accomplished, and sometimes with a precision which left me amazed. The insect made straight for the burrow as if long used to every path in the neighbourhood; but at other times there would be long visitation and repeated searches.

If the difficulty become serious, the prey, which is an embarrassing load in a hurried exploration, is laid in some obvious place, on a tuft of thyme or grass, where it can be easily seen when wanted. Freed from this burden the Ammophila resumes an active search. As she hunted about I have

traced with a pencil the track made by her. The result was a labyrinth of lines, with curves and sudden angles, now returning inward and now branching outward—knots and meshes and repeated intersections—a maze, showing how perplexed and astray was the insect.

The shaft found and the stone lifted, she must return to the prey, not without some uncertainty when comings and goings have been too many. Although it was left in a place obvious enough, the Ammophila often seems at a loss when the time comes to drag it home; at least, if there be a very long search for the burrow, one sees her suddenly stop and go back to the caterpillar, feel it and give it a little bite, as if to make sure that it is her very own game and property, hurrying back to seek for the burrow, but returning a second time if needful, or even a third, to visit her prey. I incline to believe that these repeated visits are made to refresh her memory as to where she left it.

This is what happens in very complex cases, but generally the insect returns without difficulty to the spot whither its vagrant life may have led it. For guide it has that local memory whose marvellous feats I shall later have occasion to relate. As for me, in order to return next day to the burrow hidden under the little flat stone, I dared not trust to my memory, but had to use notes, sketches, to take my bearings, and stick in pegs—in short, a whole array of geometry.

The temporary closing of the burrow with a flat stone as practised by A. sabulosa and A. holosericea appears unknown to the two other species; at least I

never saw their homes protected by a covering. This is natural in the case of A. hirsuta, for, I believe, this species hunts the prey first and then burrows near the place of capture. As provender can therefore be at once stored it is useless to take any trouble about a cover. As for A. holosericea, I suspect there is another reason for not using any temporary door. While the two others only put one caterpillar in each cell, she puts as many as five, but much smaller ones. Just as we ourselves neglect to shut a door where some one is constantly passing to and fro, perhaps this Ammophila neglects to place a stone on a well which she will go down at least five times within a short space of time. All four lay up caterpillars of moths for their larvæ. A. holosericea chooses, though not exclusively, those slender, long caterpillars known as Loopers. They move as a compass might by opening and closing alternately, whence their expressive French name of Measurers. The same burrow includes provisions of varied colours—a proof that this Ammophila hunts all kinds of Loopers so long as they are small, for she herself is but feeble and the larva cannot eat much, in spite of the five heads of game set before it. If Loopers fail, the Hymenopteron falls back on other caterpillars equally small. Rolled up from the effect of the sting which paralysed them, all five are heaped in the cell; the top one bears the egg for which the provender is destined.

The three other Ammophilæ give but one caterpillar to each cell. True—size makes up for this; the game selected is corpulent, plump, amply sufficing the grub's appetite. For instance, I have

taken out of the mandibles of A. holosericea a caterpillar fifteen times her own weight—fifteen times!—an enormous sum if you consider what an expenditure of strength it implies to drag such game by the nape of its neck over the endless difficulties of the ground. No other Hymenopteron tried in the scales with its prey has shown me a like disproportion between spoiler and capture. The almost endless variety of colouring in the provender exhumed from the burrows or recognised in the grasp of the various species also proves that the three have no preference, but seize the first caterpillar met with, provided it be neither too large nor too small, and belongs to the moths. The commonest prey are those gray caterpillars which infest the plant at the junction of a root and stem just below the soil.

That which governs the whole history of the Ammophila, and more especially attracted my attention, was the way in which the insect masters its prey and plunges it into the harmless state required for the safety of the larva. The prey, a caterpillar, is very differently organised from the victims which we have hitherto seen sacrificed—Buprestids, Weevils, Grasshoppers, and Ephippigers. It is composed of a series of segments or rings set end to end, the three first bearing the true feet which will be those of the future butterfly; others bear membranous or false feet special to the caterpillar and not represented in the butterfly; others again are without limbs. Each ring has its ganglion, the source of feeling and movement, so that the nerve system comprehends twelve distinct centres well separated from each other,

without counting the œsophageal ganglion placed under the skull, and which may be compared to the brain.

We are here a long way from the nerve centralisation of the Weevil and Buprestis that lends itself so readily to general paralysis by a single stab; very far too from the thoracic ganglia which the Sphex wounds successively to put a stop to the movements of her crickets. Instead of a single centralised point—instead of three nerve centres—the caterpillar has twelve, separated one from another by the length of a segment and arranged in a ventral chain along the median line of the body. Moreover, as is the rule among lower animals, where the same organ is very often repeated and loses power by diffusion, these various nervous centres are largely independent of each other, each animating its own segment, and are but slightly disturbed by disorder in neighbouring ones. Let one segment lose motion and feeling, yet those uninjured will none the less remain long capable of both. These facts suffice to show the high interest attaching to the murderous proceedings of the Hymenopteron with regard to its prey.

But if the interest be great, the difficulty of observation is not small. The solitary habits of the Ammophila,—their being scattered singly over wide spaces, and their being almost always met with by mere chance,—almost forbid, as in the case of Sphex occitanica, any experiment being prepared beforehand. Long must a chance be watched for and awaited with unalterable patience, and one must know how instantly to profit by it when at last it comes just when least expected. I have waited for such a chance for

years and years, and then, all at once, I got the opportunity with a facility for observation and clearness of detail which made up for the long waiting.

At the beginning of my observations I succeeded twice in watching the murder of the caterpillar, and saw, as far as the rapidity of the operation allowed, that the sting of the Hymenopteron struck once for all at the fifth or sixth segment of the victim. To confirm this I bethought myself of making sure which ring was stabbed by examining caterpillars which I had not seen sacrificed, but had carried off from their captors while they were being dragged to the burrow; but it was vain to use a microscope,—no microscope can show any trace of such a wound. This was the plan adopted. The caterpillar being quite still, I tried each segment with the point of a fine needle, measuring the amount of sensibility by the greater or less pain given. Should the needle entirely transpierce the fifth segment or the sixth, there is no movement. But prick even slightly one in front or behind, the caterpillar struggles with a violence proportioned to the distance from the poisoned segment. Especially does the least touch on the hinder ones produce frantic contorsions. So there was but one stab, and it was given in the fifth or sixth segment.

What special reason is there that one or other of these two should be the spot chosen by the assassin? None in their organisation, but their position is another thing. Omitting the Loopers of Ammophila holosericea, I find that the prey of the others has the following organisation, counting the head as the first segment:—Three pairs of true feet on rings two, three, and four; four pairs of membranous feet on

rings seven, eight, nine, and ten, and a last similar pair set on the thirteenth and final ring; in all eight pairs of feet, the seven first making two marked groups—one of three, the other of four pairs. These two groups are divided by two segments without feet, which are the fifth and sixth.

Now, to deprive the caterpillar of means of escape, and to render it motionless, will the Hymenopteron dart its sting into each of the eight rings provided with feet? Especially will it do so when the prey is small and weak? Certainly not: a single stab will suffice if given in a central spot, whence the torpor produced by the venomous droplet can spread gradually with as little delay as possible into the midst of those segments which bear feet. There can be no doubt which to choose for this single inoculation; it must be the fifth or sixth, which separate the two groups of locomotive rings. The point indicated by rational deduction is also the one adopted by instinct. Finally, let us add that the egg of the Ammophila is invariably laid on the paralysed ring. There, and there alone, can the young larva bite without inducing dangerous contorsions; where a needle prick has no effect, the bite of a grub will have none either, and the prey will remain immovable until the nursling has gained strength and can bite farther on without danger.

With further researches doubts assailed me, not as to my deductions, but as to how widely I might extend them. That many feeble Loopers and other small caterpillars are disabled by a single stab, especially when struck at so favourable a point as the one just named, is very probable in itself, and, moreover, is

shown both by direct observation and by experiments on their sensibility with the point of a needle. But Ammophila sabulosa and hirsuta catch huge prey, whose weight, as already said, is fifteen times that of the captor. Can such giant prey be treated like a poor Looper? Can a single stab subdue the monster and render it incapable of harm? If the fearsome gray worm strike the cell walls with its strong body, will it not endanger the egg or the little larva? One dares not imagine a *tête-à-tête* in the small cell at the bottom of the burrow between the frail, newly-hatched creature and this kind of dragon—still able to coil and uncoil its lithe folds.

My suspicions were heightened by examination as to the sensitiveness of the caterpillar. While the small game of Ammophila holosericea and hirsuta struggle violently if pricked elsewhere than in the part stabbed, the large caterpillars of A. sabulosa, and above all of A. hirsuta, remain motionless, no matter which segment be stimulated. They show no contortions or sudden twisting of the body, the steel point only producing as a sign faint shudderings of the skin. As the safety of a larva provided with such huge prey requires, motion and feeling are almost quite destroyed. Before introducing it into the burrow, the Hymenopteron turns it into a mass—inert indeed, yet not dead.

I have been able to watch the Ammophila use her instrument on the robust caterpillar, and never did the infused science of instinct show me anything more striking. With a friend—alas! soon after snatched from me by death—I was returning from the tableland of Les Angles after preparing snares to put

the cleverness of Scarabæus sacer to the proof, when we caught sight of an Ammophila hirsuta very busy at the foot of a tuft of thyme. We instantly lay down very close by. Our presence noways alarmed the insect, which alighted for a moment on my sleeve, decided that since her visitors did not move they must be harmless, and returned to her tuft of thyme. Well used to the ways of Ammophila, I knew what this audacious tameness meant—she was occupied by some serious affair. We would wait and see. The Ammophila scratched in the ground round the collar of the plant, pulling up thin little grass roots, and poked her head under the tiny clods which she raised up, ran hurriedly, now here, now there, round the thyme, visiting every crack which gave access under it; yet she was not digging a burrow, but hunting something hidden underground, as was shown by manœuvres like those of a dog trying to get a rabbit out of its hole. And presently, disturbed by what was going on overhead and closely tracked by the Ammophila, a big gray worm made up his mind to quit his abode and come up to daylight. It is all over with him; the hunter is instantly on the spot, gripping the nape of his neck and holding on in spite of his contortions. Settled on the monster's back the Ammophila bends her abdomen, and methodically, deliberately—like a surgeon thoroughly familiar with the anatomy of his subject—plunges a lancet into the ventral surface of every segment, from the first to the last. Not one ring is omitted; with or without feet each is stabbed in due order from the front to the back.

This is what I saw with all the leisure and ease

required for an irreproachable observation. The Hymenopteron acts with a precision of which science might be jealous; it knows what man but rarely knows; it is acquainted with the complex nervous system of its victim, and keeps repeated stabs for those with numerous ganglia. I said "It knows; is acquainted": what I ought to say is, "It acts as if it did." What it does is suggested to it; the creature obeys, impelled by instinct, without reasoning on what it does. But whence comes this sublime instinct? Can theories of atavism, of selection, of the struggle for life, interpret it reasonably? For my friend and myself it was and is one of the most eloquent revelations of the ineffable logic which rules the world and guides the unconscious by the laws which it inspires. Stirred to the heart by this flash of truth, both of us felt a tear of emotion rise to our eyes.

XVI

THE BEMBEX

NOT far from Avignon, on the right bank of the Rhône opposite the mouth of the Durance, is one of my favourite points for the observations about to be recorded. It is the Bois des Issarts. Let no one deceive himself as to the value of the word "bois"-wood, which usually gives the idea of a soil carpeted with fresh moss and the shade of lofty trees, through whose foliage filters a subdued light. Scorching plains, where the cicada grinds out its song under pale olives, know nothing of such delicious retreats full of shade and coolness.

The Bois des Issarts is composed of thin and scattered groups of ilex, which hardly lessen the force of the sun's rays. When I established myself during the dog days in July and August, I used to settle myself at some spot in the wood favourable for observations. I took refuge under a great umbrella, which later lent me most unexpected aid of another kind, very valuable too, as my story will show in good time. If I had neglected to equip myself with this article, embarrassing enough in a long walk, the only way to avoid sunstroke was to lie at full length

behind some heap of sand, and when my temporal arteries beat intolerably, the last resource was to shelter my head at the mouth of a rabbit hole. Such are the means of getting cool in the Bois des Issarts.

The soil, unoccupied by any woody vegetation, is almost bare and composed of a fine, arid, very light sand, heaped by the wind in little hillocks where the stems and roots of the ilex hinder its blowing about. The slope of such hillocks is generally very smooth, from the extreme lightness of the material, which runs down into the least depression, thus restoring the regularity of the surface. It is enough to thrust a finger into the sand, and then to withdraw it in order immediately to cause a downfall, which fills up the cavity and re-establishes the former state of things without leaving any trace. But at a certain depth, varying according to the more or less recent date of the last rains, the sand retains a dampness which keeps it stable, and lends a consistency allowing of slight excavations without roof and walls falling in. A burning sun, a radiant blue sky, sand slopes yielding without the least difficulty to the strokes of the Hymenopteron's rake, abundant game for the larvæ, a peaceful site rarely troubled by the foot of the passer-by,—all unite here in this paradise of the Bembex. Let us see the industrious insect at work.

If the reader will come under my umbrella, or profit by my rabbit burrow, this is the sight which will meet him towards the end of July. A Bembex (B. rostrata) arrives of a sudden and alights without hesitation or investigation at a spot which, as far as I see, differs in nothing from the rest of the

sandy surface. With her front tarsi, which, armed with stiff rows of hairs, suggest at once broom, brush, and rake, she begins to dig a subterranean dwelling, standing on her four hind feet, the two last slightly apart, while the front ones alternately scratch and sweep the loose sand. The precision and rapidity of the action could not be greater were the circular movement of the tarsi worked by a spring. The sand, shot backward under the creature, clears the arch of its hind legs, trickling like a liquid in a continuous thread, describing a parabola and falling some eight inches away. This dusty jet, constantly fed for five or ten minutes, is enough to show with what dizzy rapidity the tools are used. I could quote no second example of equal swiftness, which yet in no way detracts from the elegance and free movements of the insect as it advances and retires, now on one side, now on another, without allowing the parabola of sand to stop.

The soil hollowed is of the lightest kind. As the Hymenopteron excavates, the sand near falls and fills the cavity. In the landslip are mingled little bits of wood, decayed leaf-stalks, and grains of gravel larger than the rest. The Bembex picks these up in her mandibles, and, moving backward, carries them to a distance, returning to sweep again, but always lightly, without attempting to penetrate into the earth. What is the object in this surface labour? It would be impossible to learn from a first glance, but after spending many days with my dear Hymenoptera, and grouping together the scattered results of my observations, I think I divine the motive of these proceedings.

The nest is certainly there underground, at the depth of a few inches: in a little cell, dug in cool firm sand, is an egg, perhaps a larva, which the mother feeds daily with flies, the invariable food of Bembex larvae. She must be able at any moment to penetrate to this nest, carrying on the wing, between her feet, the nursling's daily ration, just as a bird of prey arrives at its eyrie carrying game for its brood in its claw. But while the bird returns to a nest on some inaccessible shelf of rock, without any difficulty beyond the weight of its prey, the Bembex must undertake each time the hard work of mining, opening afresh a gallery blocked and closed by ever-sliding sand in proportion as she proceeds. The only stable part of this underground abode is the spacious cell inhabited by the larva amid the remains of a fortnight's feast; the narrow vestibule entered by the mother to go down to the cell, or come forth for the chase, gives way each time, at all events at the upper end, built in dry sand, rendered even looser by her constant goings and comings. Thus at each entrance or exit the Hymenopteron must clear out a passage. The exit offers no difficulties, even should the sand have the same consistency as when first stirred; the insect's movements are free; it is safe under cover, can take its time and use tarsi and mandibles at its leisure. Going in is another matter. The Bembex is embarrassed by her prey, pressed to her body by her feet, so that there is no free use of the mining tools. What is more serious is that impudent parasites—veritable bandits in ambush—are crouching here and there about the burrow watching her difficult

entrance to hurriedly drop their egg on the game just as it disappears into the gallery. If they succeed, the son of the house, the Hymenopteron's nursling, will perish, starved by greedy guests.

The Bembex seems aware of this danger, and arranges so as to enter quickly, without serious obstacles, so that the sand blocking the door should yield to a mere push from her head, aided by a rapid sweep of the forelegs. To this end she, so to say, sifts the materials round her abode. In leisure moments, when the sun shines and the larva has its food, and does not need her care, the mother rakes before her door, and puts on one side all the tiny bits of wood, of over-large gravel or leaves, which might get on her path and bar the passage at the perilous moment of return. The Bembex which we saw so hard at work was busy sifting so as to make access to her abode easier; the materials of the vestibule are examined, minutely sorted, and cleared of every encumbrance. Who can tell whether the rapid labour and joyous activity of the insect do not express in their own way her maternal satisfaction and happiness in caring for the roof of the cell which has received the precious trust of the egg? As the Bembex confines herself to exterior household cares without seeking to penetrate the sand, everything must be in order within, and there is nothing pressing to do. We may wait, but for the time the insect will teach us nothing more. Let us therefore examine the underground dwelling.

By lightly scratching the bank with the blade of a knife just where the Bembex was oftenest seen, one soon discovers the entrance hall, which, blocked

as it is for part of its length, is none the less recognisable by the special look of the materials moved about. This passage, a finger's-breadth in size, rectilinear or winding, longer or shorter, according to the nature of the ground, measures eight to twelve inches. It leads to a single chamber, hollowed in damp sand, with walls undaubed with mortar, which might prevent landslips and lend polish to the rough surface. Enough if the ceiling lasts while the larva is being fed up. Future falling-in matters little when the larva is enclosed in its stout cocoon—a kind of strong box, which we shall see in process of construction. In workmanship the cell is as rustic as possible, being merely a rude excavation with no well-determined form, low roofed, and of a size which might hold two or three nests.

Within lies one head of game—one only—quite small and quite insufficient for the voracious nursling for whom it is destined. It is a golden green-fly, Lucilia Cæsar, a dweller in tainted meat, and is quite motionless. Is it really dead or only paralysed? This will be cleared up later. Just now let us observe the cylindrical egg upon its side, white, slightly curved, and a couple of millimetres in length. It is a Bembex egg. As we have foreseen from the mother's behaviour, there is no pressing household business; the egg is laid and a first ration provided for the needs of the feeble larva, which ought to hatch in twenty-four hours. For some time the Bembex need not re-enter her hole, confining herself to keeping a good lookout in the neighbourhood, or possibly making new burrows and laying there egg after egg, always in a separate cell.

This peculiarity of beginning to lay in food by a single small piece of game is not peculiar to Bembex rostrata; all the other species do the same. Open any cell after the egg is laid, and you always find it glued to the side of a Dipteron—all the food there is; moreover, this first ration is invariably small, as if the mother had sought some specially tender mouthful for her frail nursling. Another motive, the freshness of the food, may also have guided her choice. Later we will look further into the matter. This first ration—always a moderate one—varies much, according to the frequency of such or such a kind of game in the neighbourhood. It is sometimes a Lucilia Cæsar, sometimes a Stomoxys, or some small Eristalis, or a delicate Bombylius clad in black velvet, but the commonest is a Sphærophoria with a slender abdomen. This fact (and it has no exception) of storing the nest with but a single Dipteron,—a ration far too meagre for a larva with a voracious appetite,—at once puts us on the track of the most remarkable habit of the Bembecidæ. Hymenoptera whose larvæ live on prey heap into each cell the whole number of victims needed by the grub, which is hatched and lives alone,—an egg having been laid on one fly and the dwelling closed up. The larva has before it its whole store of food. But the Bembex is an exception to this rule. First a head of game is brought to the cell and an egg dropped on it. Then the mother leaves the burrow, which closes of its own accord; besides which she takes care to rake the surface smooth, and hide the entrance from every eye but her own.

Two or three days pass: the egg hatches and

the small larva eats up its choice ration. Meanwhile, the mother remains near: one may see her licking the sugary exudations on the flower-heads of Eryngium campestre for nourishment, then settling with enjoyment on the burning sand, whence she doubtless surveys the exterior of her dwelling, or she sifts the sand at its entrance, then flies off and vanishes—perhaps to excavate other cells to be stored in a like manner. But however prolonged her absence, she does not forget the young larva so scantily provided for; maternal instinct teaches her the hour when the grub has finished its food and needs new sustenance. Then she comes back to the nest whose invisible entrance she knows right well how to find, and penetrates the hollow—this time laden with a larger prey. This deposited, she goes out again, and awaits outside the time for a second expedition. It soon comes, for the larva shows a devouring appetite. Again the mother arrives with fresh provender.

During almost a fortnight, while the larva is growing, the meals follow each other thus, one by one, as it needs them, and so much the nearer together as the nursling grows stronger. Toward the end of the fortnight the mother requires all her activity to supply the glutton's appetite as it crawls heavily amid the remains of its repasts—wings, feet, and horny rings of abdomens. Each moment she returns with a new capture or comes forth for the chase. In short, the Bembex brings up her family from hand to mouth without storing provisions, like the bird which brings a beakful of food to the little ones still in the nest. Among the numerous proofs

of this method of upbringing—one very singular in a Hymenopteron which feeds its family on prey—I have already mentioned the presence of the egg in a cell where but one little fly is found as provender—always one—never more. Another proof is the following one, which does not require any special moment for its ascertainment.

Let us examine the burrow of a Hymenopteron, which provides beforehand for its larvæ. If we choose the moment when the insect enters with a captive, we shall find in the cell a certain number of victims already stored, but never a larva—not even an egg, for this is only laid when the provisions are complete. The egg deposited, the cell is closed, and the mother returns no more. It is, therefore, only in burrows where the mother's visits are no longer needed that one can find larvæ amid the larger or smaller heap of food. Visit, on the other hand, the dwelling of a Bembex as she enters with the produce of her chase, and you are sure to find a larva, larger or smaller, amid the remains of food already devoured. The ration now brought is to continue a repast which has been going on for several days, and is to be prolonged upon the produce of future expeditions. If we can make this examination towards the end of the larva's upbringing,—an advantage which I have enjoyed at pleasure,—we shall find upon a great heap of fragments a portly larva, to which the mother is still bringing food. The Bembex only ceases to do so and to leave the cell definitely when the larva, distended by a wine-coloured pap, refuses to eat, and reclines, thoroughly stuffed, on the remains of wings and feet of the game which it has devoured.

Each time that she penetrates into the burrow on returning from the chase, the mother brings but a single fly. Were it possible by means of the remains contained in a cell where the larva is full grown to count the victims served up, one would at least know how often the Hymenopteron visited its burrow after the egg is laid. Unfortunately, these broken meats—munched and munched again in moments of scarcity—are for the most part unrecognisable. But on opening a cell with a less advanced nursling, one can examine the provisions, some of the prey being yet whole or nearly so, and others, more numerous, being trunks in sufficiently good preservation to be distinguishable. Incomplete as it is, the enumeration thus obtained strikes one with surprise, as showing what activity the Hymenopteron must display to satisfy the demands of such a table. Here is one of the bills of fare observed.

At the end of July around the larva of Bembex Julia, which had almost reached the third of its full size, I found the prey of which the following is the list:—Six Echinomyia rubescens—two whole and four in pieces; four Syrphus corollæ—two whole, two in fragments; three Gonia atra—all intact, and one just brought by the mother, which had enabled me to discover the burrow; two Pollenia ruficollis—one whole, one attacked; a Bombylius reduced to pulp; two Echinomyia intermedia in bits; and finally two Pollenia floralis, also in bits—total, twenty. Certainly we have here a bill of fare as abundant as varied, but as the larva had only attained to a third of its complete size, the entire bill of fare might well amount to sixty articles.

The verification of this magnificent sum-total is easily obtained. I myself will undertake the maternal cares of the Bembex, and feed the larva until it is thoroughly satisfied. I place the cell in a little cardboard box furnished with a layer of sand. On this bed is placed the larva with due regard to its delicate epidermis. Around it, without omitting a single fragment, I arrange the provender with which it was supplied, and return home with the box still in my hand, to avoid any shake which might turn it topsy-turvy and endanger my charge during a journey of several miles. Any one who had seen me on the dusty road to Nîmes, exhausted with fatigue and bearing religiously in my hand, as the only result of my painful journey, a wretched grub, distending itself with a heap of flies, would assuredly have smiled at my simplicity. The journey was achieved without hindrance; when I got home the larva was peacefully consuming its flies as if nothing had happened. On the third day the provisions taken from the burrow were finished, and the grub with its pointed mouth was searching in the heap of remains without finding anything to its taste. The dry, horny, juiceless pieces which it got hold of were rejected with disgust. The moment had come for me to continue the food supply. The first Diptera within reach must content my prisoner; I slew them by squeezing them between my fingers, but did not crush them. Three Eristalis tenax composed the first ration, together with a Sarcophaga. In twenty-four hours all were devoured. The next day I provided two Eristalis and four house-flies. This sufficed for that day, but nothing was left over. I

went on thus for a week, giving the grub each morning a larger ration. On the ninth day it refused to eat and began to spin its cocoon. The bill of fare for the week's high feeding amounted to sixty-two items, chiefly Eristalis and house-flies, which, added to the twenty items found entire or in fragments in the cell, formed a total of eighty-two.

Possibly I may not have brought up my larva with the wholesome frugality which the mother would have shown; there may have been some waste in the daily rations, provided all at once and left entirely to the discretion of the grub. I fancied that in some particulars things did not go on exactly as in the cell, for my notes have such details as: "In the alluvial sands of the Durance I discovered a burrow into which Bembex oculata had taken a Sarcophaga agricola. At the bottom of the gallery was a larva, numerous fragments, and some Diptera entire—namely, four Sphærophoria scripta, one Onesia viarum, and two Sarcophaga agricola, counting that which the Bembex had brought under my very eyes." Now it must be remarked that one half of this game, the Sphærophoria, was quite at the bottom of the cell—under the very jaws of the larva, while the other half was still in the gallery—on the threshold of the cell—consequently out of the grub's reach, as it could not leave its place. It would seem that when game abounds, the mother disposes provisionally of her captures on the threshold of the cell, and forms a reserve on which she draws as need arises, especially on rainy days, when all labour is at a standstill. This economy in distributing food would prevent the waste unavoidable with my larva perhaps too sump-

tuously treated. I subtract then from the sum obtained, and reduce it to sixty pieces of medium size, between that of the house-fly and Eristalis tenax. This would be about the number of Diptera given by the mother to the larva when the prey is middle-sized, as is the case with all the Bembecids of my district except B. rostrata and B. bidentata, which especially favour the gadfly. For these the number of slain would be from one to two dozen, according to the size of the Dipteron, which varies greatly in the gadfly species.

In order not to return to the kind of provisions, I give a list of the Diptera observed in the burrows of the six kinds of Bembex, which are the subject of this essay.

(1) B. olivacea, Rossi. Once only have I seen this species, at Cavaillon, preying on Lucilia Cæsar. The five next are common round Avignon.

(2) B. oculata, Jur The Dipteron upon which the egg is laid is generally a Sphærophoria, especially S. scripta; sometimes it is a Geron gibbosus. Further provender consisted in Stomoxys calcitrans, Pollenia ruficollis, P. rudis, Pipiza nigripes, Syrphus corollæ, Onesia viarum, Calliphora vomitoria, Echinomyia intermedia, Sarcophaga agricola, Musca domestica. The usual food was Stomoxys calcitrans, of which I have found fifty or sixty in a single burrow.

(3) Bembex tarsata, Lat. It, too, lays its egg on Sphærophoria scripta; but it also hunts Anthrax flava, Bombylius nitidulus, Eristalis æneus, E. sepulchralis, Merodon spinipes, Syrphus corollæ, Helophilus trivittatus, Zodion notatum. Its favourite prey consists in Bombylius and Anthrax.

(4) Bembex Julii (a new species). The egg hatches either on a Sphærophoria or a Pollenia floralis, and the provender is a mixture of Syrphus corollæ, Echinomyia rubescens, Gonia atra, Pollenia floralis, P. ruficollis, Clytia pellucens, Lucilia Cæsar, Dexia rustica, Bombylius.

(5) Bembex rostrata. This is above all a captor of gadflies. It lays its egg on a Syrphus corollæ, or a Lucilia Cæsar, but then only brings to the larva large game belonging to the various kinds of Tabanus.

(6) Bembex bidentata. Another ardent hunter of gadflies. I have never seen it with other game, and do not know on what the egg is laid.

This variety of provisions shows that the Bembecids have no exclusive tastes, and attack one and all of the species of Diptera which are offered by the chances of the chase. They seem, however, to have some favourites—one species especially choosing Bombylius, another Stomoxys, and a third and fourth, Gadflies.

XVII

HUNTING DIPTERA

AFTER this bill of fare for Bembecids in the larva state, we must seek the motive which causes these Hymenoptera to adopt a mode of storage exceptional among Fossors. Why, instead of laying up sufficient food and dropping an egg on it, which would allow the cell to be closed at once without need of returning, does the Hymenopteron oblige itself to come and go perpetually for a fortnight from the fields to the burrow and back again, toiling every time through the sand to issue forth and hunt, or bring back prey? The explanation is that the food must be fresh—an all-important matter, for the grub absolutely refuses game which is at all high, with a hint of decay; like the larvæ of all Fossors, it must have fresh provisions—always fresh provisions.

We have seen in the case of the Cerceris, Sphex, and Ammophila how the mother resolves the feeding problem, by placing beforehand in the cell a sufficient quantity of game, and also that of keeping it for weeks perfectly fresh—nay, almost alive, though motionless —in order to secure the safety of the grub which

feeds on the prey. This marvel is brought about by the most skilful means known to physiology. The poisoned sting is sent into the nerve centres once or oftener, according to the construction of the nervous system, and the victim retains all which we call life, except power of motion.

Let us see if the Bembex practises this deep science of murder. Diptera taken from between the feet of their captor as the latter enters the burrow mostly seem quite dead. They are motionless; only in rare cases are there some slight convulsions of the tarsi—the last vestiges of life soon to be extinct. The same appearance of complete death is found, as a rule, in insects not really killed but paralysed by the skilful stab of a Cerceris or a Sphex. The question as to life or death can, therefore, only be decided by the manner in which the victims keep fresh.

Placed in little paper twists or glass tubes, the Orthoptera of the Sphex, the caterpillars of the Ammophila, the Coleoptera of the Cerceris, preserve flexibility of limb and freshness of colour, and the normal state of their intestines, for weeks and months. They are not corpses, but bodies plunged in a lethargy from which there will be no awakening. The Diptera of the Bembex behave quite otherwise. Eristalis, Syrphus,—in short, all which are brightly coloured,—soon lose their brilliance; the eyes of certain gadflies, magnificently gilded, and with three purple bands, soon grow pale and dim, like the gaze of a dying man. All these Diptera, great and small, placed in paper twists where air circulates, dry up and grow brittle in two or three days,

while all kept from evaporation in glass tubes, where the air is stagnant, grow mouldy and decay. So they are dead—really dead—when carried to the larva. If some few preserve a little life, a few days, a few hours ends all. Not being clever enough to use its sting, or for some other reason, the assassin kills its victims outright.

Knowing this complete death of the prey at the moment when it is seized, who would not admire the logic of the Bembecid's manœuvres? How methodical all is, and how one thing brings about another in all which the wary Hymenopteron does! As the food could not be stored without its decaying at the end of two or three days, it cannot be laid in wholesale at the beginning of a phase of life destined to last at least a fortnight, and there must be a hunt and distribution of provisions day by day, in proportion to the larva's growth. The first ration—that on which the egg is laid—will last longer than the others, and must be small, for the little grub will take several days to eat it, and if too big it would go bad before it was finished. Therefore it will not be a huge gadfly or a corpulent Bombylius, but a small Sphærophoria, or something of that kind, as a tender meal for a still frail larva. Later, and gradually larger, will come the bigger joints.

In the mother's absence the burrow must be closed to prevent awkward intrusions, but the entrance must be one opened quickly, without serious difficulty, when the Hymenopteron returns loaded with prey, and laid in wait for by audacious parasites. These conditions would be wanting in a tenacious soil, such as that in which the mining Hymenoptera habitually

establish themselves. The wide-open entrance would each time require long and painful labour, whether to close it with earth or gravel, or to clear it. The domicile, therefore, must be hollowed in earth with a very light surface, in dry, fine sand, yielding at once to the least effort of the mother, and which slips and closes the entrance like floating tapestry, which, pushed back by the hand, allows entrance and then drops back. Such is the sequence of acts, deduced by human reason, and put into practice by the wisdom of the Bembex.

Why does the spoiler kill the prey instead of paralysing it? Is it want of skill with the sting? Is it a difficulty arising from the organisation of the Diptera or from the manœuvres of the chase? I must own, at once, that I have failed to put a Dipteron, without killing it, into that state of complete immobility into which it is so easy to plunge a Buprestis, a Weevil, or a Scarabæus, by injecting a little drop of ammonia, on the point of a needle, into the thoracic ganglia. It is difficult to render your subject motionless; when it no longer moves, actual death has occurred, as is proved by its speedy decay or desiccation. But I have too much confidence in the resources of instinct,—I have seen the ingenious solution of too many problems,—to believe that a difficulty, though insurmountable for the experimenter, can baffle an insect; therefore, without casting doubt on the Bembex's capacity for murder, I should be inclined to seek other motives.

Perhaps the Dipteron, so thinly cuirassed, of so little substance,—so lean, in short,—could not, when

paralysed by a sting, resist evaporation, and would dry up in two or three weeks. Consider the slender Sphærophoria—the larva's first mouthful. What is there in this body to evaporate? An atom—a mere nothing. The body is a thin strip—its two walls touch. Could such prey form a basis for preserved food when a few hours would evaporate its juices, unrenewed by nutrition? To say the least, it is doubtful.

Let us proceed to consider the manner of hunting, by way of throwing a final light on the subject. In prey withdrawn from the clasp of a Bembex, one may not infrequently observe indications of a capture made in haste, as best might be, in the chances of a wild struggle. Sometimes the Dipteron has its head turned backward, as if its neck had been twisted, its wings are crumpled, and its hairs, if it have any, are ruffled. I have seen one with the body ripped open by a bite from the mandibles, and legs lost in the battle. Usually, however, the prey is intact.

No matter. Considering that the game has wings prompt in flight, the capture must be made with a suddenness which it seems to me hardly allows of obtaining paralysis without death. A Cerceris with its heavy weevil, a Sphex engaged with a corpulent grasshopper or a paunched ephippiger, an Ammophila holding its caterpillar by the nape of its neck, have all three the advantage over a prey too slow to avoid attack. They may take their time, choose at leisure the exact spot where the sting shall penetrate, and, in short, can act with the precision of a physiologist who uses his scalpel on a patient laid upon the

operating table; but for the Bembex it is another matter. At the least alarm the prey is off, and its power of wing defies that of the pursuer. The Hymenopteron must pounce on its prey, without measuring its attack or calculating its blow, like a hawk hunting over the fallows. Mandibles, claws, sting—all weapons—must be used at the same moment in the hot battle, to end as fast as possible a struggle in which the least indecision would give the prey time to escape. If these conjectures agree with facts, the Bembex can only secure a dead body, or, at all events, a prey wounded to death.

Well, my calculations are right. The Bembex attacks with an energy which would do honour to a bird of prey. To surprise one on the chase is no easy matter, and it would be useless to lay in a stock of patience and watch near the burrow, for the insect flies to a distance, and it is impossible to follow its rapid evolutions, and doubtless its manœuvres would be still unknown to me but for the help of an article from which I should assuredly never have expected a like service—namely, the umbrella which served me as a tent amid the sands of Issarts.

I was not the only one to profit by its shade; my companions were usually numerous. Gadflies of different kinds would take refuge under the silken canopy, and roost peacefully here and there on the outspread silk, rarely failing to appear when the heat was overpowering. To pass the hours when I was unemployed, I used to observe with pleasure their great gilded eyes shining like carbuncles under my canopy, or their grave movements when some spot

of their ceiling became too much heated, and they were forced to move a little way.

One day—ping! ping! the tense silk was resounding like the parchment of a drum. Perhaps an acorn has fallen on my umbrella. Soon after, close together, came ping! ping! Has some idle jester come to disturb my solitude, and fling acorns or little pebbles on my umbrella? I came out of my tent and inspected the neighbourhood. Nothing! The blow was repeated. I looked upward, and the mystery was explained. The Bembecids of the neighbourhood, which prey on gadflies, had found out the rich store of food which was keeping me company, and were darting audaciously under my shelter to seize the gadflies on the ceiling. Nothing could have been better. I had only to keep quiet and observe.

Every moment a Bembex entered like a sudden flash, and darted up to the silken ceiling, which resounded with a dull thud. A tumult went on aloft, in which one could not distinguish attacker from attacked, so lively was the *mêlée*. The struggle was very brief; almost at once the Hymenopteron retired with a captive between its feet. The dull band of gadflies drew a little back all round on this sudden irruption, which decimated them, but without leaving the treacherous shelter. It was so hot outside; wherefore move? Plainly, such swift attack and prompt departure with the prey does not allow the Bembex to use a poignard according to rules. The sting no doubt fulfils its office, but is directed with no precision towards such spots as are exposed by the chances of the combat. To slay outright the

half-murdered gadfly, still struggling between the feet of its assassin, I have seen the Bembex chew the head and thorax of her victim. This habit, peculiar to the Bembecids, shows that the Bembex desires death, not paralysis, since she ends the life of the Diptera with so little ceremony. Everything considered, I think that on the one side the nature of the prey, so quickly dried up, and on the other, the difficulties of so vehement an attack, are the reasons why the Bembecids serve up dead prey to their larvæ, and consequently provide it daily.

Let us follow the Hymenopteron when it returns with its captive closely clasped to the burrow. Here is one—B. tarsata—coming loaded with a Bombylius. The nest is placed at the sandy foot of a vertical slope, and the approach of the Bembex is announced by a sharp humming, somewhat plaintive, and only ceasing when the insect has alighted. One sees her hover above the bank, then descend, following the vertical line slowly and cautiously, still emitting the sharp hum. If her keen gaze should discover anything unusual, she delays her descent, hovers a moment, ascends again, redescends, then flies away, swift as an arrow. In a few moments she returns. Hovering at a certain height she appears to inspect the locality, as if from the top of an observatory. The vertical descent is resumed with most circumspect deliberation; finally, she alights without hesitation at a spot which to my eye has nothing to distinguish it from the rest of the sandy surface. The plaintive note ceases at once. She must have alighted somewhat by chance, since the most practised eye could not distinguish one spot from another

BEMBEX ROSTRATA TAKING GADFLY TO ITS NEST; BEMBEX ROSTRATA MINING

[*To face p.* 240.

on the sandy tract. She will have dropped down somewhere near her hole, whose entrance she will now seek, marked since her last exit not only by the natural falling in of materials, but by her scrupulous sweeping. No! she does not hesitate in the least—does not feel about—does not seek. All have agreed that the organs fitted to direct insects in their researches reside in the antennæ. At the moment of returning to the nest I see nothing special in their play. Without once losing hold of the prey the Bembex scratches a little in front of her just where she alighted, pushes with her head, and straightway enters clasping the Dipteron to her body. The sand falls in, the door closes, and the Hymenopteron is at home.

I have watched the Bembex return home a hundred times, yet it is always with fresh astonishment that I see the keen-sighted insect at once detect an entrance which nothing indicates, and which indeed is jealously hidden—not indeed when she has entered (for the sand, more or less fallen in, does not become level, and now leaves a slight depression, now a porch incompletely obstructed), but always after she comes out, for when going on an expedition she never neglects to efface the traces of the sliding sand. Let us await her departure, and we shall see that she sweeps before her door and levels everything scrupulously. When she is gone, I defy the keenest eye to rediscover the entrance. To find it when the sandy tract was of some extent I was forced to have recourse to a kind of triangulation, and how often did my triangle and efforts of memory prove vain after a few hours' absence! I

was obliged to have recourse to a stake—in other words, a grass stalk planted before the entrance—a means not always effectual, for it often disappeared during the frequent settings to rights of the outside of the Bembex's nest.

XVIII

A PARASITE—THE COCOON

I HAVE just described the Bembex hovering, loaded with her prey, above the nest, and descending with a vertical flight—very slow, and accompanied by a plaintive hum. This cautious, hesitating mode of arrival might suggest that the insect was examining from above in order to find her door, and trying to recall the locality before alighting. But I shall show that there is another motive. In ordinary conditions, when nothing alarms her, she comes suddenly, without hovering or plaintive hum or hesitation, and alights at her threshold, or close by. So faithful is her memory that she has no need to search about. Let us find out the cause of the hesitating arrival just described.

The insect hovers, descends slowly, mounts again, flies off and returns, because serious danger threatens. That plaintive hum is a sign of anxiety, and is never produced unless there is peril. But who is the enemy? Is it I, sitting by and watching? Not in the least; I am quite unimportant—a block unworthy of notice. The dreaded enemy—the foe who must be avoided at any price—is on the ground, perfectly

still upon the sand, near the nest. It is a small Dipteron—nothing at all to look at—of inoffensive aspect. This petty fly is the terror of the Bembex. That bold assassin of Diptera, who so promptly breaks the neck of colossal gadflies, full fed on blood from an ox's back, dares not enter her home because she sees herself watched by another Dipteron—a mere pigmy, which would scarce make one mouthful for her larva.

Why not pounce on it and get rid of it? The Bembex flies fast enough to overtake it, and, small as it is, the larvæ would not disdain it, since they eat all and every Diptera. Yet the Bembex flies in terror before an enemy which one bite would hew in pieces. I really feel as though I saw a cat wild with terror before a mouse. The ardent pursuer of Diptera is driven away by a Dipteron, and that one of the smallest! I bow before the facts without any hope of ever comprehending this reversal of parts. To be able to get rid easily of a mortal enemy, who is meditating the ruin of your family, and who might make a feast for them—to be able, I say, to do this, and not to do it when the foe is there, within reach, watching you, defying you,—is the height of folly in an animal. Folly, however, is not rightly the word: let us rather talk of the harmony of creatures, for since this wretched little Dipteron has its small part to play in the great whole of things, the Bembex must needs respect it and basely flee before it,—otherwise long ago there would have been no more Dipteron of this species in the world.

Let us trace the history of this parasite. Among Bembex nests there are found, and that frequently,

some which are occupied at the same time by the larvæ of the Hymenoptera and by other larvæ—strangers to the family and greedily sharing their food. These strangers are smaller than the nursling of the Bembex—shaped like a tear, and of the colour of wine, from the food paste which can be seen through their transparent bodies. Their number varies from six to ten or more. They belong to a kind of Dipteron, as may be perceived from their form and from the pupæ which one afterwards finds in their place. The demonstration is completed by bringing them up one's self in a box, where, fed daily with flies, and laid on sand, they turn into pupæ, whence issue the following year little Diptera—Tachinids of the genus Miltogramma.

This is the Dipteron which, when lying in wait near the burrow, awakens such alarm in the Bembex. Her terror is only too well founded. This is what happens in the dwelling. Around the heap of food which the mother wears herself out in providing in sufficient quantity, sit in company with the legitimate nursling from six to ten hungry guests, who put their sharp mouths into the general heap as unceremoniously as if they were at home. Concord seems to reign at table. I have never seen the legitimate larva take offence at the indiscretion of the strangers, nor observed these attempt to trouble its repast. All keep themselves together, and eat peaceably without annoying their neighbours.

So far all would be well, were it not that a grave difficulty arises. However active may be the mother-nurse, it is clear that she cannot meet such a consumption of food. She has to be incessantly on the

wing to feed one larva: what must happen if there are a dozen gluttons to provide for? The result of this enormous increase of family can only be want, or even famine, not for the larvæ of the Dipteron (which develop more rapidly than that of the Bembex, profiting by the days when abundance still reigns, their host being yet in early youth), but for the latter, who reaches the moment of metamorphosis without being able to make up for lost time. Besides, when the first guests become pupæ and leave the table free to it, others come, as long as the mother visits the nest, and complete its starvation.

In burrows invaded by numerous parasites the Bembex larva is undoubtedly much smaller than one would expect from the heap of food consumed, the remains of which encumber the cell. Limp, emaciated,—only half or a third of its proper size,—it vainly tries to spin a cocoon, the silk for which it has not got, and it perishes in a corner of the cell, amid the pupæ of guests more fortunate than itself. Or its end may be yet more tragic. Should provender fail, or the mother delay too long in returning with food, the Diptera devour it. I ascertained this black deed by bringing up the brood myself. All went well as long as food was plentiful, but if through neglect, or on purpose, the daily supply failed, next day or the day after I was sure to find the Diptera larvæ greedily rending that of the Bembex. Thus, when the nest is invaded by parasites, the legitimate larva is fated to perish either by hunger or a violent death, and this it is which makes the sight of Miltogramma prowling round the nest so odious to the Bembex.

The Bembex is not the only victim of these parasites: the burrows of one and all of the mining Hymenoptera are invaded by Tachinids, especially by the Miltogramma. Various observers—notably Lepeletier de Saint Fargeau—have spoken of the manœuvres of these impudent Diptera; but as far as I know none have perceived the very curious case of parasitism at the expense of the Bembex—very curious, because the conditions are quite different. Nests of other Fossors are stored beforehand, and the Miltogramma drops an egg on the prey just as it is being carried in. The provender stored and her egg laid, the Hymenopteron closes up the cell where thenceforward live the legitimate larva and the strangers, unvisited in their prison. Thus, the robbery committed by the parasite is unknown to the mother, and must consequently remain unpunished.

With the Bembex it is quite otherwise. The mother constantly returns during the fortnight that she is bringing up the larva; she knows that her offspring is living among numerous intruders, who appropriate the greater part of the food; every time that she brings provender she touches and feels at the bottom of her den these detestable guests, who, far from contenting themselves with remains, seize what is best. She must perceive, however small her powers of arithmetic may be, that twelve are more than one; besides, she would discover this from the disproportion between the consumption of food and her means of hunting, and yet, instead of seizing these bold intruders and bundling them out, she serenely tolerates them. Tolerates! Why, she

feeds them and brings them their rations, and perhaps feels as much tenderness for them as for her own larva. It is a new version of the cuckoo story in yet more singular circumstances. The theory that the cuckoo, almost as big as a sparrow-hawk and coloured like it, should look imposing enough to introduce an egg unresisted into the nest of the weak hedge-sparrow, and that the latter, over-awed perhaps by the alarming look of her toad-faced nursling, should accept and care for the stranger, has something in its favour. But what shall we say of a sparrow which, turning parasite, should go with splendid audacity and intrust her eggs to the eyrie of a bird of prey—the nest of the sparrowhawk itself—the sanguinary devourer of sparrows? What should we say of the bird of prey who should accept the charge and bring up the brood tenderly? It is precisely thus that the Bembex acts,—she, a captor of Diptera who yet brings up other Diptera—a huntress who distributes food to a prey whose last repast will be her own disembowelled offspring! I leave to cleverer people the task of explaining these amazing relations.

Let us observe the tactics employed by the Tachinid, whose object is to confide her egg to the nest of the miner. It is an invariable rule that the fly should never penetrate into the burrow, even if left open and the owner absent. The crafty parasite would take good care not to entangle itself in a passage, where, having no possibility of flight, it might pay dearly for its effrontery. The only moment for its designs—a moment watched for with the greatest patience—is that when the Hymenopteron

enters the gallery, clasping her prey. At that instant, brief as it is, when the Bembex or any other miner has half her body within the entrance, and is about to disappear underground, the Miltogramma arrives on the wing, perches on the prey slightly, projecting beyond the hinder end of the Bembex, and while she is delayed by the difficulties of entering, the Miltogramma, with unparalleled promptitude, lays an egg on the prey, or two, or even three eggs, successively. The hesitation of the Bembex, embarrassed by her load, lasts but the twinkling of an eye; but that matters not—it is long enough for the fly to accomplish its misdeed without being dragged beyond the threshold. What must not be the suppleness of organs to achieve this instantaneous laying of the egg! The Bembex disappears, herself introducing the enemy, and the Tachinid goes and crouches in the sun, close to the burrow, and meditates fresh crimes. If one would make sure that the Dipteron's eggs have really been deposited during this rapid manœuvre, it suffices to open the burrow and follow the Bembex to the bottom of her abode. The prey which one takes from her bears underneath at least one egg—sometimes more, according to the length of the delay at the entrance. These very minute eggs could only belong to a parasite, and if any doubt remained, you can bring up the brood in a box, and the result will be Diptera larvæ—later pupæ, and finally Miltogramma.

The fly shows wonderful sagacity in the moment selected by it—the only one which could permit of her carrying out her purpose with neither peril nor vain efforts. The Bembex, half-way through

the entrance, cannot see her enemy audaciously perched on the hind quarters of the prey, or, if she suspects the bandit's presence, cannot drive it away, having no freedom of movement in the strait passage, and in spite of all precautions to facilitate speedy entrance, cannot always vanish underground with the celerity required, so quick is the parasite. In fact, this is the only propitious moment, since prudence forbids the Dipteron to penetrate into the den, where other Diptera, far stronger than itself, are served up as food for the larvæ. Outside, in the open air, the difficulty is insurmountable, so great is the vigilance of the Bembex. Let us give a moment to the arrival of the mother, when the nest is being watched by the Miltogramma.

Some of these flies—more or fewer, generally three or four—have settled on the sand and are quite motionless, all gazing at the burrow, the entrance of which they know very well, carefully hid though it be. Their dull-brown colour, their large crimson-red eyes, their intense stillness, have often made me think of bandits who, dressed in a dark material, with a red kerchief over their heads, are lying in wait to do some evil deed. The Hymenopteron comes, loaded with prey. Had she no anxieties she would alight straightway at her door. Instead, she hovers at a certain height, descends slowly and circumspectly, hesitates, and vibrates her wings, producing a plaintive hum denoting apprehension. She must have seen the malefactors. They too have seen the Bembex. The movement of their red heads shows that they are following her with their eyes; every gaze is fixed on the coveted

booty. Then come marches and counter-marches of cunning versus prudence.

The Bembex drops straight down with an imperceptible flight, as if she let herself sink gently, making a parachute of her wings. Now she is hovering just above the ground; the flies take wing, placing themselves one and all behind her,—some nearer, some farther,—in a geometrical line. If she turns round to disconcert them, they turn too, with a precision which keeps them all in the same straight line; if she advances, so do they; if she draws back, they draw back too, measuring their flight, now slow, now stationary, on that of the Bembex at the head of the file. They do not attempt to fling themselves on the desired object, their tactics being merely to hold themselves in readiness in the position of rearguard, so as to avoid any hesitation when the rapid final manœuvre shall come.

Sometimes, wearied out by their obstinate pursuit, the Bembex alights, and the flies instantly settle on the sand, still behind her, and keep quite still. She rises again, with a sharper hum—the sign no doubt of increasing indignation; the flies follow her. One last means remains to throw the tenacious Diptera off the track; the Bembex flies far away—perhaps hoping to mislead the parasites by rapid evolutions over the fields. But the crafty flies are not taken in; they let her go, and settle down again on the sand round the burrow. When the Bembex returns the same manœuvres begin again until the obstinacy of the parasites has exhausted her prudence. At a moment when her vigilance fails, the flies are

instantly there. Whichever is at the most favourable point drops upon the vanishing prey, and the thing is done—the egg is laid.

There is ample evidence that the Bembex is conscious of danger, and knows how disastrous for the future of her nest is the presence of the hated fly; her long efforts to throw the parasites off her track, her hesitation and flights, leave not a doubt on the subject. How is it then, I ask myself once more, that the enemy of Diptera should allow herself to be annoyed by another Dipteron—a tiny robber, incapable of the least resistance, which, if she chose, she could destroy instantly? Why, when once free from the prey which hampers her, does she not pounce on these ill-doers? What is needed to exterminate the evil brood around her burrow? Merely a battle which would take but a few instants. But the harmony of those laws which govern the preservation of species will not have it so, and the Bembex will always allow herself to be harassed without ever learning from the famous "struggle for life" the radical means of extermination. I have seen some which, pressed too closely, let fall their prey and flew off wildly, but without any hostile demonstration, although dropping their game left them full liberty of action. The prey, so ardently desired a moment earlier by the Tachinidæ, lay on the ground at the mercy of them all, and not one cared about it. It had no value for the flies, whose larvæ need the shelter of a burrow. It was valueless also to the Bembex, who came back, felt it for an instant and left it disdainfully. The little break in her custody of it had rendered her suspicious of it.

Let us end this chapter by the history of the larva. Its monotonous life offers nothing remarkable during the two weeks while it eats and grows. Then comes making a cocoon. The slight development of silk-producing organs does not allow of a dwelling of pure silk, like those of the Ammophila and Sphegidæ—made of several wrappers which protect the larva, and later the nymph, from damp in the ill-protected, shallow burrow during autumn rains and winter snows. Yet this Bembex burrow is in worse conditions than those of the Sphex, being made at a depth of only a few inches in very permeable soil. To fashion a sufficient shelter the larva supplements by its industry the small amount of silk at its disposal. With grains of sand artistically put together and connected by silky matter, it constructs a most solid cocoon—impenetrable to damp.

Three general methods are employed by fossorial Hymenoptera to construct the dwelling in which metamorphosis is to take place. Some hollow burrows at a great depth under a shelter, and then the cocoon consists of a single wrapper, so thin as to be transparent. Such is the case with Philanthidæ and Cerceris. Others are content with a shallow burrow in open ground; but in that case they have silk enough for manifold wrappings of the cocoon, as with Sphegidæ, Ammophila, and Scolia; or if the quantity be insufficient, they use agglutinated sand—as, for instance, the Bembex and Palarus. One might take a Bembex cocoon for a solid kernel, so compact and resistent is it. The form is cylindrical—one end rounded, the other pointed.

The length is about two centimetres. Outside it is slightly wrinkled and coarse, but within the walls are smoothed by a fine varnish.

Rearing at home has enabled me to follow every detail of the construction of this curious piece of architecture—a real strong box which can brave all the severity of the weather. First of all the larva pushes away the remains of its feast into a corner of the cell, or the compartment arranged for it in a box with paper partitions. Having cleared a space, it affixes to the walls of its abode threads of a beautiful white silk, forming a spidery web which keeps the heap of food-remains at a distance, and serves as scaffolding for the work to come.

This work consists of a hammock, suspended far from anything that can defile it, in the centre of threads stretched from wall to wall. Fine, beautiful white silk is the only material used. The shape is that of a sack open at one end, with a wide circular orifice, closed at the other and ending in a point; a fisherman's basket gives a very fair idea of it. Then the edges of the aperture are permanently kept apart by numerous threads fastened to the neighbouring walls. The tissue of the bag is extremely fine, allowing all that the grub does to be seen.

Things had been in this state since the previous evening, when I heard the larva scratching in the box. On opening, I found my captive busy scratching the cardboard walls with the tips of its mandibles, its body half out of the bag. Already it had made considerable progress, and a heap of little fragments were piled before the opening of the hammock, to be utilised later. For lack of other

materials it would doubtless have used these scrapings for its constructions, but I thought it better to provide according to its tastes and give it sand. Never did Bembex larva build with such sumptuous material. I poured out for my prisoner sand for drying writing,—sand well sprinkled with gilded grains of mica,—before the opening of the bag, which was in a horizontal position, suitable to the work which would follow. The larva, half out of its hammock, chose its sand almost grain by grain, routing in the heap with its mandibles, and, if one too bulky presented itself, it was seized and cast aside. The sand being sorted, the larva introduced a certain quantity with its mouth into the silken fabric, then retired into its sack and began spreading the materials in a uniform layer on the inner surface, then glued together various grains and inlaid them in the fabric, with silk for cement. The outer surface was constructed more slowly. These grains were carried singly and fixed on with silk gum.

This first deposit of sand only concerns the anterior part of the cocoon—that half which ends in the opening. Before turning round to work at the back part, the larva renews its store of materials and takes certain precautions, so as not to be embarrassed in its masonry. The sand heaped before the entrance might slip inside and hinder the builder in so narrow a space. The grub foresees this, and glues some grains together, making a coarse curtain of sand, which stops up the orifice, imperfectly indeed, but enough for the purpose. These precautions taken, the grub labours at the back part of the cocoon. From time to time it turns round to get

fresh materials from outside, tearing away a corner of the protecting curtain, and through this window grasping the materials needed. The cocoon is still incomplete—wide open at the upper end and without the spherical cap needed to close it. For this final bit of work the grub provides itself abundantly with sand, and then pushes away the heap before the entrance. A silken cap is now woven and fitted close to the mouth of this primitive basket. On this silken foundation are deposited, one by one, the sand grains kept in the interior and cemented with silk-spittle. This lid completed, the larva has only to give the last finish to the interior of the dwelling and glaze the walls with varnish, to protect its tender skin from the roughness of the sand.

The hammock of pure silk and the cap which later closes it are evidently only scaffolding intended to support the masonry of sand and to give it a regular curve. One might compare them to the constructions used by builders when making an arch or vault. The work being completed, the silken support disappears, partly lost in the masonry, and partly destroyed by contact with rough earth, and no trace remains of the ingenious method employed to put together a construction perfectly regular, yet made of a material so little coherent as is sand. The spherical cap which closes the original basket is a separate work, adjusted to the main body of the cocoon. However well the two pieces are fitted and soldered, the solidity is not such as the larva would obtain had it built the whole dwelling continuously. Thus, on the circumference of the cover there is a circular line less capable of resistance, but this is not

a fault of construction. On the contrary it is a fresh perfection. The insect would experience grave difficulty in issuing from its strong box, so thick are the walls, did not the line of junction, weaker than the rest, apparently save much effort, as it is usually along this line that the cover is detached when the perfect Bembex emerges.

I have called the cocoon a strong box. It is indeed a solid article, both from its shape and the nature of its materials. Landslips or falling sand cannot alter its form, since the strongest pressure of one's fingers cannot always crush it. Thus it matters little to the larva if the ceiling of its burrow, dug in loose soil, should sooner or later fall in, and it need not fear, even should a passing foot press down the thin covering of sand ; it runs no risks when once enclosed in its stout shelter. Nor does damp endanger it. I have immersed Bembex cocoons for a fortnight in water without finding any trace of damp inside them. Ah ! why cannot we have such waterproof for our dwellings ? To sum up : the cocoon, of graceful oval shape, appears rather the product of patient art than the work of a grub. For any one not behind the scenes, the cocoons which I saw in process of construction with the sand from my inkstand might well have been precious articles of some unknown industry—great beads starred with golden dots on a ground of lapis lazuli, destined for the necklace of some Polynesian belle.

XIX

THE RETURN TO THE NEST

THE Ammophila digging her well late in the day leaves her work after stopping the entrance with a stone, flits away from one flower to another, goes into a new neighbourhood, and yet next day can return with a caterpillar to the abode hollowed out the evening before, notwithstanding her want of acquaintance with the locality—often new to her; the Bembex, loaded with prey, alights with almost mathematical precision on the threshold of a dwelling blocked by sand and rendered uniform with the rest of the sandy surface. Where my sight and memory are at fault, theirs have a certainty verging on infallibility. One would say that the insect possessed something more subtle than mere recollection—a kind of intuition of locality with which nothing in us corresponds—in short, an indefinable faculty which I call memory for lack of any other expression by which to designate it. The unknown cannot be named. In order to throw if possible a little light on this point in the psychology of animals I instituted a series of experiments, which I will now describe.

The first had for its subject Cerceris tuberculata,

which hunts the Cleonus. About 10 a.m. I took a dozen females busy at the same bank and of the same colony, either hollowing or storing burrows. Each was enclosed in a twist of paper, and all were put into a box. About two kilometres from the nests I freed my captives, first marking them with a white dot in the middle of the thorax by means of a straw dipped in an indelible colour, in order to recognise them later. They flew on every side—some here, some there, but only a few paces, alighting on blades of grass and passing their forelegs over their eyes for a moment, as if dazzled by the bright sunshine to which they were suddenly restored. Then they took flight—some earlier, some later; and one and all took unhesitatingly a straight line south, *i.e.* in the direction of their home. Five hours later I returned to the common territory of the nests. Almost directly I saw two of my white-dotted Cerceris working at their burrows. Soon a third came in, with a weevil between her feet. A fourth soon followed—four out of twelve in a quarter of an hour was enough for conviction; I judged it useless to wait longer; what four could do, the others could, if indeed they had not already done it, and one may very well suppose that the eight absentees were out hunting, or perhaps had retired into the depths of their burrows. Thus, carried to a distance of two kilometres, in a direction and by a way which they could not possibly perceive from the depths of their paper prison, the Cerceris—at all events part of them—had returned home.

I do not know to what distance they go hunting; possibly they know the country round for some two kilometres. In that case they would not have been

far enough away, and came home by their local knowledge. The experiment had to be tried again at a greater distance, and from a point which the Cerceris could not possibly know.

I therefore took nine females from the colony whence I had got them in the morning; three of these had been already experimented upon. Again they were conveyed in a dark box—each imprisoned in a paper twist. The starting-place was to be the neighbouring town of Carpentras, about three kilometres from the burrows. I meant to release them not amid fields as before, but in a street in the midst of a populous quarter, where the Cerceris, with their rustic habits, had assuredly never penetrated. As the hour was late I put off the experiment, and my captives spent the night in their prison cells.

The next morning, towards eight o'clock, I marked them with a double white spot on the thorax to distinguish them from those of the evening before, which had only one, and set them free successively in the middle of the street. Each mounted vertically, as if to get as soon as possible from between the houses and gain a wide horizon, then rising above the roofs, instantly and energetically turned its flight south. And it was from the south that I brought them into the town, and their burrows are south. Nine times with my nine prisoners did I obtain this striking result—that an insect quite beyond its bearings should not hesitate a moment what direction to take to regain its nest.

Some hours later I too was at the burrows. I saw several of my yesterday's Cerceris with a white dot, but none of the last set free. Had they been

unable to find the way back? Were they out hunting, or in their galleries recovering from the excitement of such a trial? I do not know. The next morning I came again, and had the satisfaction of finding at work, as active as if nothing extraordinary had happened to them, five Cerceris with two white dots. Three kilometres of distance,—the town with its houses, roofs, and smoky chimneys—all so novel to my rustic Cerceris,—had proved no obstacle to their return home.

Taken from its brood and carried an enormous distance, the pigeon returns promptly to its dovecote. If one were to consider the length of journey in proportion to the size of the animal, how superior to the pigeon is the Cerceris carried away three kilometres and returning to its burrow! The size of the insect does not equal a cubic centimetre, while that of the pigeon must quite equal the cube of a decimetre, if it does not exceed it. The bird, a thousand times larger than the Hymenopteron, ought, in order to rival it, to find its dovecote at a distance of 3000 kilometres—thrice the greatest length of France from north to south. I do not know if a carrier-pigeon has ever shown such prowess, but wing-power and yet more lucidity of instinct cannot be measured by yards. Nor can we here consider the question of size, and one can only see in the insect a worthy rival to the bird without deciding which has the advantage.

Are the two guided by memory when placed by man beyond their bearings and carried to great distances—into regions with which they are unacquainted and in unknown directions? Is memory

as quick when, having reached a certain height at which they can in some sort take their bearings, they launch themselves with all their power of wing towards that part of the horizon where are their nests? Is it memory which traces their aerial way across regions seen for the first time? Evidently not. It is not possible to recollect the unknown. The Hymenopteron and the bird know nothing of their surroundings; nothing can have taught them the general direction which they followed when carried thither, for it was in the darkness of a closed box that the journey was made. Locality, orientation,—all is unknown, and yet they find their way. They have then as guide something better than simple memory—a special faculty, a kind of topographic consciousness of which we can form no idea, possessing nothing analogous to it.

I am now about to establish experimentally how subtle and precise is this faculty in the narrow cycle where it is applied, and also how limited and obtuse when it has to move out of habitual conditions. Such is the invariable antithesis of instinct.

A Bembex, actively engaged in feeding her larva, has left her burrow. She will return immediately with the product of the chase. The entrance is carefully stopped with sand—swept backward by the insect before departing. Nothing distinguishes it from the rest of the sandy surface. But this offers no difficulty to the Hymenopteron, who finds her doorway again with a sagacity which I have already described. Let us plan some treachery; let us perplex her by altering the state of the place. I cover the entrance with a flat stone as large as

my hand. She soon returns. The complete change made upon her threshold during her absence does not seem to cause her the slightest hesitation; at all events she alights immediately upon the stone, and tries for an instant to hollow it, not at a chance spot, but exactly over the opening of her burrow. Quickly turned aside from this attempt by the hardness of the obstacle, she traverses the stone in every direction, goes round it, slips underneath, and begins to dig in the precise direction of her dwelling.

The flat stone is too trifling an obstacle to disconcert the clever fly; let us find something better. I did not allow the Bembex to continue her excavation, which I saw would soon prove successful, and drove her far off with my handkerchief. The absence of the frightened insect for a considerable time allowed me to prepare my snares leisurely. What materials must now be employed? In these improvised experiments one must know how to turn all things to profit. Not far off on the high road is the fresh dropping of a beast of burden; here is wood for our arrow. The dropping was collected, crushed, and spread in a layer at least an inch thick on the threshold of the burrow and its surroundings over more than a quarter of a yard. Assuredly here was such a façade as never Bembex knew. Colour, the nature of the material, the effluvium,—all combined to deceive the Hymenopteron. Can she take this stretch of manure—this dung—for the front of the dwelling? She does! Here she comes; studying from above the unusual condition of the place, and settling in the middle of the layer, just opposite the entrance, routing about, making a way

through the fibrous mass, and penetrating to the sand, she promptly discovers the mouth of the passage. I stop and drive her away a second time.

Is not the precision with which the Bembex settles before her dwelling, though masked in a way so novel, a proof that sight and memory are not in such a case the only guides? What further can there be? Smell, perhaps. That is very doubtful, for the emanations from the dung could not baffle the perspicacity of the insect. Nevertheless, let us try another odour. I happen to have with me, as part of my entomological outfit, a little phial of ether. The covering of manure is swept off and replaced by a cushion of moss, not very thick, but covering a wide surface, on which I pour the contents of my phial the moment I see the Bembex coming. The over-strong emanations keep her off, but only for an instant. She alights on the moss, still reeking of ether, traverses the obstacle and penetrates to her dwelling. The etherised effluvia did not disturb her any more than did those of the manure; something surer than smell tells where her nest is.

The antennæ have been often suggested as the seat of a special sense to guide insects. I have already shown how the suppression of these organs appears to offer no obstacle to the researches of the Hymenoptera. Let us try once more in wider conditions. The Bembex is caught, its antennæ amputated to the roots, and is then released. Stung by the pain—wild with terror at being held between my fingers—the insect flies off swifter than an arrow. I had to wait a whole hour, uncertain as to its

return. However, it came, and with its invariable precision alighted quite close to its doorway, whose look I had changed for the fourth time, having covered the site with a large mosaic of pebbles the size of a nut. My work, which, compared to the Bembex, surpassed what for us are the Megalithic monuments of Brittany, or the lines of Menhirs at Carnac, was powerless to deceive the mutilated insect. Though deprived of antennæ it found the entrance in the midst of my mosaic as easily as would have done an insect under other conditions. This time I let the faithful mother go home in peace.

The site transformed four times over, the outworks of the abode changed in colour, scent, and material, the pain of a double wound,—all failed to disconcert the Hymenopteron or even to make her doubtful as to the precise locality of her doorway. I had exhausted my stratagems, and understood less than ever how the insect, if it have no special guide in some faculty unknown to us, can find its way when sight and smell are baffled by the artifices of which I have spoken. Some days later an experience gave me the opportunity to take up the problem from a new point of view. The Bembex burrow had to be bared in its whole extent, without quite destroying it, to which operation its shallowness and almost horizontal direction, and the light soil in which it was made, lent themselves readily. The sand was gradually scraped off with the blade of a knife, and thus, deprived of roof from end to end, the underground abode became a semi-canal or conduit, straight or curved, some eight inches long, open where was the entrance, and ending

in a cul-de-sac where lay the larva amid its food.

The dwelling was uncovered in full sunshine; how would the mother behave on her return? Let us consider the question scientifically. The observer may be greatly embarrassed: what I have already seen leads me to expect it. The mother's impulse is to bring food to her larva, but to reach this larva she must first find the door. Grub and entrance are the points which appear to deserve being separately examined; therefore I take away grub and food, and the end of the passage is cleared. There is nothing more to do but arm one's self with patience.

At last the Bembex arrives and makes straight for her absent door, only the threshold of which remains. There for a good hour did I see her dig, sweep the surface, send the sand flying, and persist, not in making a new gallery, but in seeking the loose sand barrier which should yield to the mere pressure of her head and let her pass easily. Instead of loose materials she finds firm soil not yet disturbed. Warned by this resistance she limits her efforts to exploring the surface, always close to where the door should be, only allowing herself to deviate a few inches. She returns to sound and sweep places already sounded and swept some twenty times, unable to leave her narrow circle, so obstinately convinced is she that the door must be there and nowhere else. With a straw I pushed her gently and repeatedly to another point. She would have none of it, and came back at once to where the door ought to have been. Now and then the gallery, turned into a semi-canal, appeared to attract

her attention, but very faintly. She would go a few steps along it, still raking, and then return to the entrance. Two or three times I saw her go the whole length of the gallery and reach the cul-de-sac where the larva should be, do a little careless raking, and hurry back where the entrance used to be, and continue searching with a patience which exhausted mine. More than an hour had passed, and still she sought on the site whence the door had disappeared.

What would happen in the presence of the larva? That was the second part of the question. To continue the experiment with the same Bembex would not have offered sufficient guarantee, as the creature, rendered more obstinate by her vain search, seemed possessed by a fixed idea, and this would have interfered with the facts which I wanted to prove. I required a new subject, concerned solely with the impulses of the actual moment. An opportunity soon came. The burrow was uncovered, as I have just said; but I did not touch the contents; larva and food were left in their places,—all was in order inside, the roof only was wanting. Well, with this open dwelling, whose every detail the eye could embrace,—vestibule, gallery, cell at the far end, with the grub and its heap of provender,—this dwelling turned into a roofless gallery at the end of which the larva was moving restlessly, under the hot sun, its mother continued the manœuvres already described. She alighted just where the entrance had been, and there it was that she hunted about and swept the sand—there that she always returned after some hasty attempt elsewhere in a circuit of a few

inches. No exploration of the gallery—no anxiety for the distressed larva; though the grub, whose delicate skin has just exchanged the gentle moisture of a cave for burning sunshine, is writhing on its heap of chewed Diptera, the mother takes no notice of it. For her it is no more than any one of the objects strewn on the sand,—a little pebble, a clod, a scrap of dried mud,—nothing more. It is undeserving of attention. This tender, faithful mother, who wears herself out in efforts to reach her nursling's cradle, cares nothing just now but for her entrance door—the door she is used to. That which goes to her maternal heart is the longing to find the well-known passage. Yet the way is open; nothing holds her back, and under her eyes wriggles the grub, the final object of her anxiety. With one spring she would be at the side of the unhappy larva who so needs help. Why does she not rush to her beloved nursling? She could dig a new habitation and get it swiftly underground. But no—she persists in seeking a way which no longer exists, while her son is grilled under her eyes. I was boundlessly surprised by this obtuse maternity, since maternity is the most powerful and most fertile in resource of all feelings which move the animal. Hardly could I have believed my eyes but for endless experiments on the Cerceris and Philanthidæ, as well as on Bembecidæ of different species. Stranger still, the mother, after long hesitation, at length entered the unroofed passage—all that was left of the corridor. She advanced, drew back, and gave a few careless sweeps without stopping. Guided by vague recollections, and perhaps by the smell of

venison exhaled from the heap of Diptera, she came occasionally as far as the end of the gallery, the very spot where lay the larva. Mother and son had met. At this moment of reunion after long anxiety, were there earnest solicitude, sign of tenderness, or of maternal joy? Whoever thinks so has only to repeat my experiment to convince himself of the contrary. The Bembex did not recognise her larva at all; it was a worthless thing, in her way,—nothing but an embarrassment. She walked over it and trampled it unheeding, as she hurried backwards and forwards. If she wanted to dig at the bottom of the cell, she rudely kicked it behind her,—pushed, upset, expelled it, as she might have treated a large bit of gravel which got in her way while at work. Thus maltreated, the larva bethought itself of defence. I have seen it seize her by one tarsus with no more ceremony than she would have shown in biting the foot of a Dipteron caught by her. The struggle was sharp, but at last the fierce mandibles let go, and the mother flew wildly away with her sharpest hum. This unnatural scene of the son biting the mother, and perhaps even trying to eat her, is unusual, and brought about by circumstances which the observer is not always able to conjure up. What one can always witness is the profound indifference of the Hymenopteron for its offspring, and the brutal disdain with which that inconvenient heap, the grub, is treated. Once she has raked out the far end of the passage, which is done in a moment, the Bembex returns to her favourite point, the threshold, to resume her useless researches. As for the grub, it continues to struggle

and wriggle wherever the maternal kicks may have landed it. It will perish unaided by its mother, who could not recognise it because she was unable to find the passage she was used to. If we return to-morrow, we shall find it in the gallery, half-broiled by the sun, and already a prey to the flies—once its own prey.

Such is the connection in acts of instinct; one leading to the next in an order that the most serious circumstances have no power to alter. After all, what was the Bembex seeking? Her larva, evidently. But to reach this larva she had to enter the burrow, and to enter the burrow she had to find the door, and the mother persists in seeking this door while the gallery lay open with provender and larva all before her. The ruined abode, the endangered family, were for the moment unimportant; all she could think of was the familiar passage reached through loose sand. Let all go—habitation and inhabitant—if this passage be not found! Her actions are like a series of echoes, awaking one another in a fixed order, the following one only sounding when the preceding has sounded. Not because there was any obstacle; the burrow was all open, but for want of the usual entrance the first action could not take place. That decides everything; the first echo is mute, and so all the rest are silent. What a gulf between intelligence and instinct! Through the ruins of the shattered dwelling a mother guided by intelligence rushes straight to her son; guided by instinct she stops obstinately where once was the door.

XX

MASON BEES

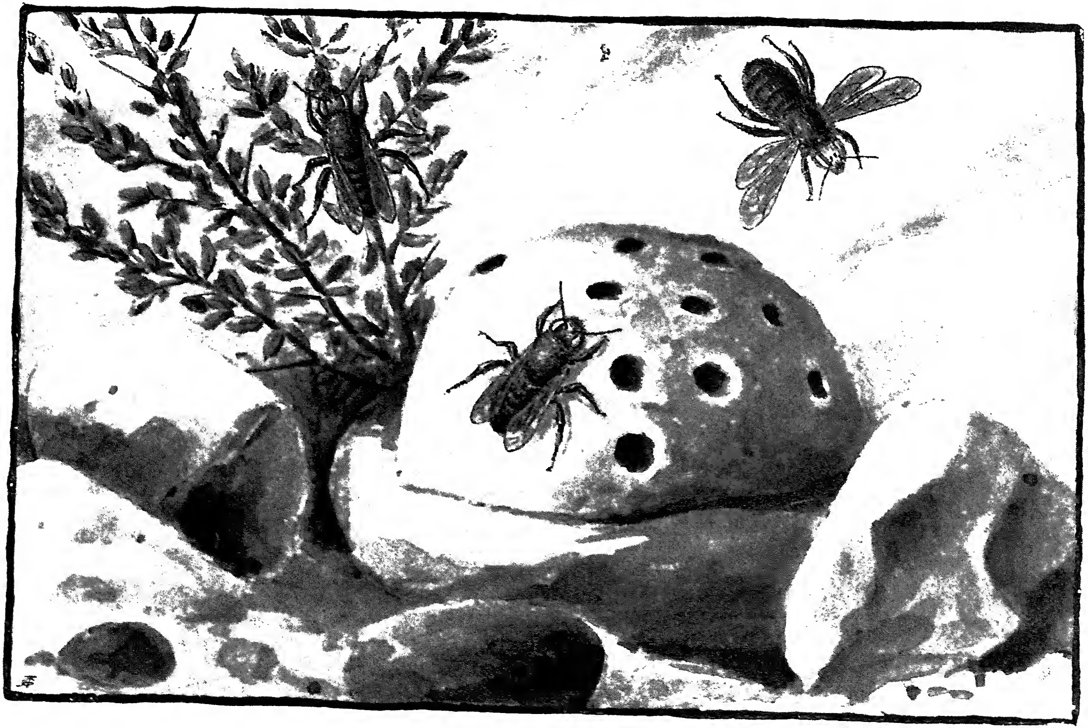
RÉAUMUR has dedicated one of his studies to the Chalicodoma of walls, which he calls the Mason Bee. I propose to resume this study, to complete it, and especially to consider it from a point of view entirely neglected by that illustrious observer. And first of all I am tempted to state how I made acquaintance with this Hymenopteron. It was when I first began to teach—towards A.D. 1843. On leaving the Normal School of Vaucluse a few months previously, with my certificate, and the *naive* enthusiasm of eighteen, I was sent to Carpentras to manage the primary school belonging to the college. A singular school it was, upon my word, notwithstanding its fine title of "Upper"!—a kind of vast cellar breathing out the damp engendered by a fountain backing on it in the street. Light came in through a door opening outward when the weather allowed of it, and a narrow prison-window, with iron-bars, and little diamond panes set in lead. For seats there was a plank fastened to the walls all round the room; in the middle was a chair guiltless of straw, a blackboard, and a bit of chalk.

Morning and evening, at the sound of a bell, there tumbled in some fifty young rascals, who, having failed to master De viris and the Epitome, were devoting themselves, as one said then, to "some good years of French." The failures at "Rosa, a Rose," came to me to learn a little spelling. Children were mingled with tall lads at various stages of education, and all distressingly agreed in playing tricks on the master—no older, even younger, than some of themselves.

I taught the little ones to read syllables, the middle ones to hold a pen in the right way while writing a few words of dictation on their knees; for the eldest I unveiled the secrets of fractions, and even the mysteries of the hypothenuse. And the only means I had to keep this restless crowd in order, give each mind appropriate food, arouse attention, expel dulness from the gloomy room whose very walls dripped melancholy, were my tongue and a bit of chalk.

For that matter there was equal disdain in the other classes for all which was not Latin or Greek. One instance will suffice to show the style in which physical science was treated, now so large a part of education. The principal of this college was an excellent man—the worthy Abbé X, who, not anxious himself to grow green peas and bacon, turned over such matters to some relation of his, and undertook to teach physical science.

Let us attend one of his lessons, which happens to be on the barometer. By good luck the college owned one. It was an old article, very dusty, hung high out of reach of profane hands, and bearing on



MASON BEES—CHALICODOMA MURARIA ON OLD NEST

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its face in large letters the words, Storm, Rain, Fine. "The barometer," began the good abbé, addressing himself to his disciples — he used a fatherly second person singular to each,—"the barometer gives notice of good or bad weather. Thou seest the words written here—Storm, Rain—thou seest, Bastien?" "I see," replies Bastien, the most mischievous of the troop. He has run through his book, and knows more about the barometer than does his professor. "It is composed," the abbé goes on, "of a curved glass tube full of mercury which rises and falls according to the weather. The small branch of this tube is open; the other—the other—we shall see as to the other. Bastien—Get on this chair, and just feel with the tip of thy finger if the long branch is open or closed. I do not quite remember." Bastien goes to the chair, stands as high as he can on tip-toe, and feels the top of the long column with a finger tip. Then, with a slight smile under the down of his dawning moustache, he replies, "Yes, exactly; yes, the long branch is open at the top. I can feel the hollow." And to corroborate his mendacious statement he went on moving his forefinger on the top of the tube, while his co-disciples, accomplices in mischief, stifled their laughter as best they could. The abbé said calmly, "That will do. Come down, Bastien. Gentlemen, write in your notes that the long branch of the barometer is open. You might forget it. I had forgotten it myself."

Thus were physics taught. Things mended, however; a master came, and came to stay,—one who knew that the long branch of a barometer is

closed. I obtained tables on which my pupils could write instead of scrawling on their knees, and as my class grew daily larger, it ended by being divided. As soon as I had an assistant to look after the younger ones, things changed for the better.

Among the subjects taught, one pleased master and pupils equally. This was out-of-door geometry, practical surveying. The college had none of the necessary outfit, but with my large emoluments—700 francs, if you please!—I could not hesitate as to making the outlay. A measuring chain and stakes, a level, square, and compass were bought at my expense. A tiny graphometer, hardly bigger than one's palm, and worth about 4s. 2d., was furnished by the college. We had no tripod, and I had one made. In short, my outfit was complete. When May came, once a week the gloomy class-room was exchanged for the fields, and we all felt it as a holiday. There were disputes as to the honour of carrying the stakes, divided into packets of three, and more than one shoulder as we went through the town felt glorified in the sight of all by the learned burden. I myself—why conceal it?—was not without a certain satisfaction at carrying tenderly the most precious part of the apparatus, the famous four-and-twopenny graphometer. The scene of operations was an uncultivated pebbly plain—a *harmas*, as we call it in these parts. No curtain of live hedge, no bushes, hindered me from keeping an eye upon my followers; here—an all important condition—I need not fear temptation from green apricots for my scholars. There was free scope for all imaginable

polygons; trapezes and triangles might be joined at will. Wide distances suggested plenty of elbow room, and there was even an ancient building, once a dovecote, which lent its vertical lines to the service of the graphometer.

Now from the very first a suspicious something caught my attention. If a scholar were sent to plant a distant stake I saw him frequently pause, stoop, rise, seek about, and stoop again, forgetful of straight line and of signals. Another, whose work it was to pick up pegs, forgot the iron spike and took a pebble instead; and a third, deaf to the measurements of the angle, crumbled up a clod. The greater number were caught licking a bit of straw, and polygons stood still, and diagonals came to grief. What could be the mystery? I inquired, and all was explained. Searcher and observer born, the scholar was well aware of what the master was ignorant of—namely, that a great black bee makes earthen nests on the pebbles of the harmas, and that in these nests there is honey. My surveyors were opening and emptying the cells with a straw. I was instructed in the proper method. The honey, though somewhat strong-flavoured, is very acceptable; I in turn acquired a taste for it, and joined the nest-hunters. Later, the polygon was resumed. Thus it was that for the first time I saw Réaumur's Mason Bee, knowing neither its history nor its historian.

This splendid Hymenopteron, with its dark violet wings and costume of black velvet, its rustic constructions on the sun-warmed pebbles among the thyme, its honey, which brought diversion from the severities

of compass and square, made a strong impression on my mind, and I wished to know more about it than my pupils had taught me—namely, how to rob the cells of their honey with a straw. Just then my bookseller had for sale a magnificent work on insects, The Natural History of Articulated Animals, by de Castelnau, E. Blanchard, and Lucas. It was enriched with many engravings which caught the eye. But alas, it had a price—such a price! What did that matter? My 700 francs ought surely to suffice for everything—food for the mind as well as for the body. That which I bestowed on the one I retrenched from the other—a balance ot accounts to which whoever takes science for a livelihood must needs resign himself. The purchase was made. That day I bled my university stipend abundantly; I paid away a whole month of it. It took a miracle of parsimony to fill up the enormous deficit.

The book was devoured—I can use no other word. There I learned the name of my black bee, and there I read for the first time details of the habits of insects, and found, with what seemed to my eyes an aureole round them, the venerated names of Réaumur, Huber, Léon Dufour; and while I turned the pages for the hundredth time, a voice whispered vaguely, "Thou too shalt be a historian of animals!" Naïve illusions! where are you? But let us banish these recollections, both sweet and sad, and come to the doings of our black bee.

Chalicodoma, house of pebbles, rough-cast mortar, a name which would be perfect did it not look odd to any one not well up in Greek. It is a

name applied to those Hymenoptera that build cells with materials such as we use for our dwellings. It is masonry, but made by a rustic workman, better used to dried clay than to hewn stone. A stranger to scientific classification (and this causes great obscurity in some of his memoirs), Réaumur called the worker after the work, and named our builders in dried clay Mason Bees, which paints them exactly. We have two kinds, C. muraria, whose history is admirably given by Réaumur, and C. sicula, which is not special to the land of Etna, as the name suggests, but is found in Greece, Algeria, and the Mediterranean region of France, especially in the department of Vaucluse, where in May it is one of the most common Hymenoptera. The two sexes of C. muraria are so unlike in colouring that a novice observing both coming out of the same nest would take them for strangers to one another. The female is of a splendid velvet black, with dark violet wings; in the male the black velvet is replaced by a bright iron-red fleece. The second species—a much smaller one—has not this difference of colour, both sexes wearing the same costume—a general mixture of brown, red, and ashy tints. Both begin to build in the beginning of May. The wing-tips, washed with violet on a bronze ground, faintly recall the rich purple of the first species.

As Réaumur tells us, C. muraria in the northern provinces chooses as the place to fix her nest a wall well exposed to the sun and not plastered, as the plaster might come off and endanger her cells. She only entrusts her constructions to a solid foundation, such as a bare stone. I see that she is equally

prudent in the south, but, for some reason unknown to me, she generally chooses some other base than the stone of a wall. A rolled pebble, often hardly larger than one's fist,—one of those with which the waters of the glacial period covered the terraces of the Rhone valley,—is her favourite support. The great ease with which such a one is found may influence her; all our slightly raised plateaux, all our arid thyme-clad ground, are but heaped pebbles cemented with red earth. In the valleys the bee can also use the stones gathered in torrent beds; near Orange, for instance, her favourite spots are the alluviums of the Aygues, with their stretches of rolled boulders no longer visited by water. Or if a pebble be wanting, she will establish her nest on a boundary stone or an enclosing wall.

Chalicodoma sicula has a yet greater variety of choice. Her favourite position is under a tile projecting from the edge of a roof. There is scarcely a little dwelling in the fields that does not thus shelter her nests. There, every spring, she establishes populous colonies, whose masonry, transmitted from one generation to another, and yearly enlarged, finally covers a very considerable surface. I have seen such a one under the tiles of a shed, which spread over five or six square yards. When the colony were hard at work, their number and humming fairly made one dizzy. The underpart of a balcony pleases them equally, or the frame of an unused window,—above all, if closed by a sun-shutter, which offers a free passage. But these are great meeting-places, where labour, each for herself, hundreds and thousands of workers. If alone, which not seldom occurs, Chali-

codoma sicula establishes herself in the first little spot she can find, so long as it has a solid basis and heat. As for the nature of this basis it matters little. I have seen nests built on bare stones and brick, on a shutter, and even on the glass panes in a shed. One thing only does not suit the bee—namely, the stucco of our houses. Prudent, like her retainer C. muraria, she would fear ruin to her cells did she entrust them to a support which might fall.

Finally, for reasons which I cannot yet satisfactorily explain, C. sicula often entirely changes her manner of building, turning her heavy mortar dwelling, which seems to require a rock to support it, into an aerial one, hung to a bough. A bush in a hedge,—no matter what—hawthorn, pomegranate, or Paliurus,—offers a support, usually about the height of a man. Ilex and elm give a greater height. The bee chooses in some thicket a bough about as thick as a straw, and constructs her edifice on this narrow base with the same mortar which would be used under a balcony or the projecting edge of a roof. When finished, the nest is a ball of earth, traversed literally by the bough. If made by a single insect it is the size of an apricot, and of a fist if several have worked at it; but this seldom occurs.

Both species use the same materials, a calcareous clay, mixed with a little sand and kneaded with the mason's own saliva. Damp spots which would facilitate labour and spare saliva to mix mortar are disdained by the Chalicodoma, which refuses fresh earth for building, just as our builders refuse old plaster and lime. Such materials when soaked with humidity would not hold properly. What is needed is a dry

powder, which readily absorbs the disgorged saliva, and forms with the albuminous principles of this liquid a kind of Roman cement, hardening quickly,—something like what we obtain with quicklime and white of egg.

A beaten road, formed of calcareous boulders crushed by passing wheels into a smooth surface like paving stones, is the quarry whence Chalicodoma sicula prefers to get mortar; whether she builds on a branch, in a hedge, or under the jutting roof of some rural habitation, it is always from a neighbouring path, or a road, or the highway, that she seeks materials—indifferent to the constant passing of beasts and travellers. You should see the active bee at work when the road is dazzling white in the hot sunshine. Between the neighbouring farm where she is building and the road where the mortar is prepared, there is the deep hum of the bees perpetually crossing each other as they come and go. The air seems traversed by constant trails of smoke, so rapid and direct is their flight. Those who go carry away a pellet of mortar as big as small shot; those who come settle on the hardest and driest spots. Their whole body vibrates as they scratch with the tips of their mandibles, and rake with their forefeet to extract atoms of earth and grains of sand, which, being rolled between their teeth, become moist with saliva and unite. They work with such ardour that they will let themselves be crushed under the foot of a passer-by rather than move. Chalicodoma muraria, however, which seeks solitude, far from human habitation, is rarely seen on beaten paths; perhaps they are too distant from the places where she builds. If

MASON BEES—CHALICODOMA SICULA AND NEST

[*To face p.* 280.

she can find dry earth, rich in small gravel, near the boulder chosen as the basis of her nest, she is contented. She may either make quite a new nest in a spot hitherto unoccupied, or over the cells of an old one, after repairing them. Let us consider the first case.

After choosing a boulder, she comes with a pellet of mortar in her mandibles, and arranges it in a ring on the surface of the pebble. The forefeet, and above all the mandibles, which are her most important tools, work the material, which is kept plastic by the gradually disgorged saliva. To consolidate the unbaked clay, angular pieces of gravel, as large as a small bean, are worked in singly on the outside of the still soft mass. This is the foundation of the edifice. Other layers are added until the cell has the required height of three or four centimetres. The masonry is formed by stones laid on one another and cemented with lime, and can stand comparison with our own. True, to economise labour and mortar, the bee uses coarse materials,—large bits of gravel, which in her case answer to hewn blocks. They are chosen singly—very hard ones, almost always with angles which, fitted together, give mutual support, and add solidity to the whole. Layers of mortar, sparingly used, hold them together. The outside of the cell thus assumes the look of a piece of rustic architecture, in which stones project with their natural inequalities; but over the inside, which requires a smoother surface in order not to wound the tender skin of the larva, is spread a wash of pure mortar—artlessly, however, as if by broad sweeps of a trowel; and when it has eaten up its honey paste, the grub;

takes care to make a cocoon and hang the rude wall of its abode with silk. The Anthophora and Halictus, whose larvæ spin no cocoon, varnish the inside of their earthen cells delicately, giving them the polish of worked ivory.

The construction, the axis of which is always nearly vertical, with an orifice opening upward, so that the fluid honey may not run out, differs a little in form, according to its basis. On a horizontal surface it rises like a little oval tower; on a vertical or slanting one it resembles half a thimble cut down its length. In this case the support—the pebble itself—completes the surrounding wall. The cell completed, the bee sets to work at once to store it. The neighbouring flowers, especially those of Genista scorpius, which in May turn the alluviums of the torrents golden, furnish sugared liquid and pollen. She comes with her crop swelled with honey, and all yellow underneath with pollen dust, and plunges head first into the cell, where for some moments one may see her work her body in a way which tells that she is disgorging honey. Her crop emptied, she comes out, but only to go in again at once—this time backwards. With her two hind feet she now frees herself from her load of pollen by brushing herself underneath. Again she goes out, and returns head first. She must stir the materials with her mandibles for a spoon, and mix all thoroughly together. This labour of mixing is not repeated after every journey, but only from time to time, when a considerable quantity has been collected. When the cell is half full, it is stored; an egg must be laid on the honey paste, and the door

has to be closed. This is all done without delay. The orifice is closed by a cover of undiluted mortar, worked from the circumference to the centre. Two days at most seem required for the whole work, unless bad weather or a cloudy day should interrupt it. Then, backing on the first cell, a second is built and stored in the same way, and a third and fourth, etc., follow, each one with honey and an egg, and closed before another is begun. Work once begun is continued until it is completed, the bee never building a new cell until the four acts required to perfect the preceding one are performed—namely, construction, provisioning, an egg, and sealing the cell.

As Chalicodoma muraria always works alone on her chosen boulder, and shows great jealousy if her neighbours alight there, the number of cells clustered on one pebble is not great—usually six to ten. Are some eight larvæ her whole progeny, or will she establish a more numerous family on other boulders? The surface of the stone would allow of more cells if she had eggs for them, and the bee might build there very comfortably without hunting for another, or leaving the one to which she is attached by habit and long acquaintance. I think, therefore, that most probably all her scanty family are settled on the same stone—at all events when she builds a new abode.

The six or ten cells composing the group are certainly a solid dwelling, with their rustic covering of gravel, but the thickness of their walls and lids—two millimetres at most—hardly seems sufficient against rough weather. Set on its stone in the open

air, quite unsheltered, the nest will undergo the heat of summer suns which will turn every cell into an oven; then will come the autumn rains which will slowly eat away the masonry, and then winter frosts which will crumble what the rain may have respected. However hard the cement may be, can it resist all these attacks, and if it can, will not the larvæ, sheltered by so thin a wall, suffer from over-heat in summer and too keen cold in winter?

Without having gone through all these arguments, the bee acts wisely. When all the cells are completed she builds a thick cover over the whole group, which, being of a material impermeable to water and almost a non-conductor, is at once a defence against heat and cold and damp. This material is the usual mortar, made of earth and saliva, only with no small stones in it. The bee lays it on,—one pellet after another, one trowelful and then a second,—till there is a layer a centimetre thick over all the cells, which disappear entirely under it. The nest is now a rude dome, about as big as half an orange; one would take it for a clod of mud, half crushed by being flung against a stone where it had dried. Nothing outside betrays its contents—no suggestion of cells—none of labour. To the ordinary eye it is only a chance splash of mud.

This general cover dries as rapidly as do our hydraulic cements, and the nest is almost as hard as a stone. A knife with a strong blade is needed to cut it. In its final shape the nest recalls in no degree the original work; one would suppose the elegant turrets adorned with pebble work, and the final dome, looking like a bit of mud, to be the work of

two different species. But scratch away the cover of cement and we recognise the cells and their layers of tiny pebbles. Instead of building on a boulder yet unoccupied, Chalicodoma muraria likes to utilise old nests which have lasted through the year without notable injury. The mortared dome has remained much as it was at the beginning, so solid was the masonry; only it is pierced by a number of round holes corresponding to the chambers inhabited by the larvæ of the past generation. Such dwellings, only needing a little repair to put them in good condition, economise much time and toil; so Mason Bees seek them, and only undertake new constructions when old nests fail them.

From the same dome come forth brothers and sisters—reddish males and black females—all descendants of the same bee. The males lead a careless life, avoiding all labour, and only returning to their clay dwellings for a brief courtship of their ladies; and they care nothing for the deserted dwelling. What they want is nectar from flower-cups, not mortar between their mandibles. But there are the young mothers, who have sole charge of the future of the family—to which of them will fall the inheritance of the old nest? As sisters they have an equal right to it—so would human justice decide, now that it has made the enormous progress of freeing itself from the old savage right of primogeniture; but Mason Bees have not got beyond the primitive basis of property—the right of the first comer.

So when the time to lay has come, a bee takes the first free nest which suits her and establishes herself

there, and woe to any sister or neighbour who thenceforward disputes possession of it. A hot reception and fierce pursuit would soon put the new-comer to flight; only one cell is wanted at the moment out of all which gape like little wells around the dome, but the bee calculates that by and by the rest will be useful, and she keeps a jealous watch on them all and drives away every visitor. I cannot remember having seen two Mason Bees working on the same pebble.

The work is now very simple. The bee examines the inside of the old cell to see where repairs are needed, tears down the rags of cocoon hanging on the walls, carries out the bits of earth fallen from the vault pierced by the inhabitant in order to get out, mortars any places out of repair, mends the orifice a little, and that is all. Then comes storage, laying an egg, and stopping up the cell. When these are successively completed, the general cover, the mortar dome, is repaired if necessary, and all is finished.

Chalicodoma sicula prefers a sociable life to a solitary one, and hundreds—nay, several thousands—will establish themselves on the under surface of the tiles on a hovel, or the edge of a roof. It is not a real society with common interests, dear to all, but merely a gathering where each works for herself and is not concerned for the rest—a throng recalling the swarm of a hive only by their number and industry. They use the same mortar as Chalicodoma muraria, equally resistent and waterproof, but finer and without pebbles. First the old nests are utilised. Every free cell is repaired, stored, and shut up. But the old ones are far from sufficing to the population, which increases rapidly year by year, and on the

surface of the nest, where the cells are hidden below the old general mortar covering, new ones are built as required. They are placed more or less horizontally, one beside another, with no kind of order. Every constructor builds as the fancy takes her, where and as she wills; only she must not interfere with her neighbour's work, or rough treatment will soon call her to order. The cells accumulate in chance fashion in this workyard, where there is no general plan whatever. Their form is that of a thimble divided down the axis, and their enclosure is completed either by adjacent cells, or the surface of the old nest. Outside they are rough, and look like layers of knotted cords corresponding to the layers of mortar. Inside the walls are level but not smooth; a cocoon will replace the absent polish.

As soon as a cell is built it is stored and walled up, as we have seen with Chalicodoma muraria. This work goes on through the whole of May. At length all the eggs are laid, and the bees, without any distinction as to what does or does not belong to them, all set to work on a common shelter of the colony—a thick bed of mortar, filling up spaces and covering all the cells. In the end the nests look like a large mass of dry mud—very irregular, arched, thickest in the middle, the primitive kernel of the establishment, thinnest at the edges, where there are fewest cells, and very variable in extent, according to the number of workers, and consequently to the time when the nest was begun. Some are not much larger than one's hand, while others will occupy the greater part of the edge of a roof, and be measured by square yards.

If Chalicodoma sicula works alone, as she often does, on the shutter of an unused window or on a stone or a branch, she behaves in just the same way. For instance, if the nest is on a bough, she begins by solidly fixing the basis of her cell on the slender twig. Then the building rises into a little vertical tower. This cell being stored and ceiled, another follows, supported both by the bough and the first cell, until six to ten cells are grouped one beside the other, and finally a general cover of mortar encloses them all together with the bough, which gives them a firm foundation.

XXI

EXPERIMENTS

BUILT on small pebbles which one can carry whither one will, remove, or interchange, without disturbing either the work of the constructor or the quiet of the inhabitants of the cells, the nests of Chalicodoma muraria lend themselves readily to experiment—the only method capable of throwing a little light on the nature of instinct. Profitably to study the physical faculties of the animal it is not enough to know how to turn to account such circumstances as a happy chance may offer to the observer: one must be capable of originating others, and vary them as much as possible and submit them to mutual control; in short, to give science a solid basis of fact one must experiment. Then some day will vanish before the evidence of exact documents the fantastic legends which cumber our books, such as the Scarabæus inviting his comrades to help in dragging his ball out of a rut, or a Sphex cutting up a fly to carry it in spite of the wind, and much more which is misused by those who desire to see in the animal world that which is not there. Thus, too, will materials be prepared which, used sooner or later by a learned

hand, will cast premature and baseless theories back into oblivion.

Réaumur generally confines himself to stating facts as they offered themselves to him in the normal course of things, and does not attempt to penetrate further into the powers of the insect by means of conditions brought about artificially. In his day there was everything to do, and the harvest was so great that the illustrious reaper hurried on to what was most urgent,—the gathering of it in, leading his successors to examine grain and ear in detail. Nevertheless, he mentions an experiment made on Chalicodoma muraria by his friend Du Hamel. The nest was placed in a glass funnel, the mouth of which was closed by a piece of gauze. Three males were hatched, which, though they had penetrated mortar hard as a stone, either did not attempt to pierce the thin gauze, or thought it beyond their power to do so. All three died under the glass. Insects generally only know how to execute that which they need to do in the common order of nature, adds Réaumur.

For two reasons the experiment does not satisfy me. First of all, to give gauze to be pierced by insects with tools made to pierce lumps as hard as tufa does not seem a happy idea; you cannot expect a navvy's pickaxe to do the same work as the scissors of a seamstress. Secondly, the transparent glass prison seems ill chosen. As soon as it had opened a way through the thickness of its earthen dome, the insect found itself in daylight, and to it daylight means final deliverance and freedom. It strikes against an invisible obstacle—the glass, and glass

does not suggest an obstacle to it. Beyond, it sees a frees pace bathed in sunshine. It exhausts itself in efforts to fly there, unable to comprehend the uselessness of struggling against this strange, invisible barrier, and perishes, obstinate and exhausted, without a glance at the gauze which closes the conical tube. The experiment must be repeated under better conditions.

The obstacle I selected was common gray paper —opaque enough to keep the insect in the dark— thin enough not to offer serious resistance to the prisoner's efforts. As there is a vast difference by way of obstacle between a paper partition and a vault of unbaked clay, let us see first if Chalicodoma muraria knows how, or rather if it is able, to pierce such a barrier. The two mandibles—pickaxes adapted to pierce hard mortar—are they also scissors capable of cutting thin material? That is the point to be ascertained.

In February, when the insect is already in the perfect state, I withdrew a certain number of cocoons uninjured from their cells, and placed each separately in a piece of reed, closed at one end naturally, open at the other. The pieces of reed represented the nest-cells. The cocoons were introduced so that the head of the insect should turn to the opening Finally, my artificial cells were closed in various ways. Some had a stopper of kneaded earth, which, when dry, answered in thickness and consistency to the mortar of the nest; others were shut by a cylinder of Sorghum vulgare at least a centimetre thick, and others with a stopper of gray paper, solidly fixed by its edges. All these bits of

cane were arranged side by side, vertically, in a box, with the artificial roof at the top, so that the insects were in the exact position they had in a nest. To open them they must do as they would had I not intervened—break through the wall overhead. I protected all with a large bell glass, and awaited the month of May when they would emerge.

The result greatly surpassed my expectations. The earthen stopper made by me was pierced with a round hole, noways differing from that made by the mason bee through its mortar dome. The vegetable barrier, so new to my prisoner,—namely, the Sorghum cylinder,—was likewise opened by a hole, apparently made by a single effort, and the gray paper allowed the insect to pass, not by bursting through, but once more by a neat round hole. So my bees were capable of work for which they were not created. To issue from their reed cells they did what probably none of their race ever did before; they perforated the Sorghum pith and made a hole in the paper just as they would have done with their natural clay ceiling. When the moment came to free themselves, the nature of the obstacle was no hindrance so long as it was not too strong for them, and thenceforward the plea of incapacity could not be evoked where a mere paper barrier was in question.

At the same time as the reed cells, two intact nests on their pebbles were placed under the glass bell. On one I pressed closely a sheet of gray paper over the mortar dome, so that to come forth the insect must first pierce the dome and then the paper, no space being left between them; while a little cone of gray paper was gummed on the stone

round the other nest, so that, as in the first case, there was a double barrier, an earthen and a paper one, with, however, this difference—that the two barriers were not close together, there being a space between them of about a centimetre at the base, and increasing as the cone rises. The results of these two experiments were quite unlike. The Hymenoptera from the nest where paper had been applied to the dome came forth by piercing the double barrier, the outer one being pierced by a clean round hole, as in the reed cells closed in the same way. For the second time it is shown that if the bee is stopped by a paper barrier, the cause is not incapacity to deal with such an obstacle. On the other hand, after they had pierced their earthen vault, the dwellers in the second nest who found the sheet of paper a little way off, made no attempt to overcome the obstacle over which they would so easily have triumphed had it been attached to the nest. They died under the cover without an effort for freedom. So had perished Réaumur's bees under his glass tube when there was but a bit of gauze between them and freedom. This fact appears to me rich in consequences. What! Here are strong insects which find penetrating tufa mere play, and a stopper of thin wood or a sheet of paper quite easy to pierce, new as these are to them, and yet these vigorous insects let themselves stupidly perish imprisoned in a cone of paper which they might have torn to bits with one bite of their mandibles. They might—but they never dreamed of doing so. The motive of their dull inertness can be only this—the insect is excellently endowed with tools and instinctive

faculties, in order to accomplish the final act of its metamorphosis, *i.e.* issuing from the cocoon or cell. Its mandibles furnish it with scissors, file, pick, and lever to cut, gnaw, and pull down not only its cocoon and wall of mortar, but any other barrier not too tenacious which may be substituted for the natural wall of its nest. Moreover,—and this is a chief condition, without which its outfit would be useless,—there is, I will not say the will to use these tools, but an inward stimulus inviting it to employ them. The hour to come forth having arrived, this stimulus awakens, and the insect sets to work to bore a passage.

In that case it matters little whether the material to be pierced is natural mortar, Sorghum pith, or paper. The imprisoning cover will not resist long It even matters little if the obstacle be thickened and a paper barrier be added to the earthen one. Both count as one if there be no interval between them, and the insect passes through them because this coming forth seems to it a single action. With the paper cone, whose wall is at a short distance, the conditions are changed, although the total thickness of barrier is really the same. The insect has done all that it was destined to do in order to free itself. To move freely on the mortar dome means to it that deliverance is achieved. It has bored its way out; the work is accomplished. But round the nest another barrier presents itself—the paper wall. To pierce through, the action already accomplished must be repeated—that action which the insect has to perform but once in its life. It must double that which naturally is but single; and it

cannot, simply because it has not the will to do it. It perishes for lack of the smallest ray of intelligence. Yet in this singular intellect it is the fashion nowadays to see a rudiment of human reason! The fashion will pass and the facts remain, bringing us back to the good old ideas of the soul and its immortal destinies.

Réaumur relates, too, how his friend Du Hamel, having seized a mason bee with his pincers when it had entered half-way into its cell, head first, to fill it with bee-bread, carried it into a room at a considerable distance from the spot where he caught it. The bee escaped and flew through the window. Du Hamel immediately returned to the nest. The mason bee reached it almost at the same time, and resumed work. It only seemed a little wilder, says the narrator.

Why were you not with me, venerated master, on the banks of the Aygues, with their stretches of pebbles, dry for three parts of the year, and an enormous torrent when it rains? I would have shown you something far better than the fugitive escaped from your pincers. You should have seen, and shared my surprise thereat, not the short flight of a mason bee, which, carried into a room near at hand, escapes and returns straight home in a neighbourhood familiar to her, but long journeys by unknown ways. You would have seen the bee, carried away by me to a long distance, return with a geographical precision which the swallow would not disown, or the martin, or the carrier-pigeon, and you would have asked yourself, as I did, what inexplicable knowledge of the map of the country guides this mother

in seeking her nest. Let us come to the facts. We must repeat on the mason bee my earlier experiments with the Cerceris—namely, carrying the insect in darkness far from the nest, marking and setting it free. In case any one should wish to repeat the experiment, I will explain my method of operation, which may make it easier for a beginner. The insect destined for a long journey must of course be captured with certain precautions. No nippers, no pincers which might maim a wing, strain it, and endanger power of flight. While the bee is absorbed in work within her cell, I cover the latter with a little glass tube. As she flies out she goes into this, and thus, without touching her, I can transfer her to a twist of paper and close it quickly. A botanical tin serves as a means of transporting the captives, each in its paper prison.

It is on the spots chosen as starting-places that the most delicate operation takes place—namely, marking each captive before freeing her. I use chalk powdered fine and moistened with a strong solution of gum arabic. Dropped somewhere on the insect with a straw, it leaves a white mark, which dries quickly and adheres to the bee's fleece. If a mason bee has to be marked, so as to distinguish her from another in an experiment of short duration, such as I shall presently describe, I only touch the tip of the abdomen with a straw charged with colour while the insect is half inside the cell, head downwards. The bee does not notice the slight touch and works on undisturbed; but the mark is not very durable, nor at a spot favourable for its preservation, since the bee frequently brushes her body to

detach pollen, and sooner or later effaces it. It is therefore in the very middle of the thorax—between the wings—that I drop the gummed chalk.

In such work it is hardly possible to wear gloves. The fingers require all their dexterity to seize the mason bee with sufficient delicacy, and to master her struggles without rough pressure. It is evident that if nothing else be gained, one is sure of stings; with a little address they can generally be avoided, but not always; one must take them with resignation. Besides, a mason bee's sting is by no means so painful as that of a hive bee. The white spot dropped on the thorax—off goes the mason bee, and the mark dries as she goes.

The first time I tried the experiment I took two mason bees busy at their nests on the boulders covering the alluvial lands along the Aygues, not far from Serignan, and carried them to my home at Orange, where I freed them after marking each. According to the Ordnance map the distance between the two places is about four kilometres in a right line. The captives were freed in the evening at an hour when bees begin to leave off work, so it was likely that my two would spend the night somewhere near.

The next morning I returned to the nests. It was still too cold, and work was suspended. When the dew was dried the masons set to work. I saw a bee, but without the white spot, taking pollen to one of the two nests whence had come the travellers whom I expected. A stranger, having found the cell unoccupied, and having expatriated the owner, had established herself there, unaware that it was

the property of another. Perhaps she had been storing it since the previous evening. Towards ten o'clock, at the hottest time, suddenly the proprietor arrived. Her rights as first occupier were inscribed as far as I was concerned in irrefutable characters in white chalk on her thorax. Here was one of my travellers come back.

Over waves of corn, over fields of red sainfoin, she had accomplished the four kilometres, and returned to her nest after collecting booty on the way, for she came,—worthy creature that she was!—all yellow underneath with pollen. To return from the verge of the horizon was a marvel, but to do so with a well-furnished pollen brush was really sublime economy! A journey, even if compulsory, is always for a bee an opportunity of collecting food. She found the stranger in her nest. "What's all this? You just wait!" and fell furiously on the other, who perhaps had thought no wrong. Then there were hot pursuits through the air. From time to time the two hovered almost motionless, facing one another with a couple of inches between them, doubtless measuring each other with their eyes, and humming abuse at one another. Sometimes one, sometimes the other alighted on the nest in question. I expected to see a wrestle, and stings used; but I was mistaken. The duties of maternity spoke too imperiously to allow them to risk life, and wipe out the injury in a mortal duel. All was limited to hostile demonstrations and a few tussles leading to nothing.

However, the proprietor seemed to draw redoubled courage and strength from consciousness of her

rights. She encamped permanently on the nest and received the other bee each time that she ventured to approach with an irritated quiver of the wings in token of just indignation. The stranger finally withdrew discouraged, and instantly the mason resumed work as actively as if she had not undergone the chances and changes of a long journey.

Yet another word as to rights of property. While a mason bee is absent it is not unusual for some homeless vagabond to visit the nest, take a liking to it, and set to work, sometimes at the same cell, sometimes at the next, if there are several free, as often happens with old nests. When the first occupant returns she does not fail to drive away the intruder, who always ends by getting the worst of it, so lively and invincible is the real owner's sense of property. Reversing the savage Prussian maxim, "Strength before right," here right comes before strength; otherwise the constant retreat of the intruder would be quite inexplicable, since the latter's strength is in no way inferior to that of the real owner. If she has less audacity it must come from not feeling braced by the sovereign strength of being right, which decides among equals, even in the brute creation.

The second of my two travellers did not appear, either on the day when the first came, nor later. I decided to make another experiment—this time with five subjects. Place of starting and arrival, distance and hours, were the same. I found three at the nests on the following day; two were missing.

It is therefore quite clear that Chalicodoma

muraria carried away four kilometres, and, set free where she certainly could never have been before, can return home. But why did one out of two, and two out of five, fail to do so? What one could do, why not another? Are they not equally gifted with the faculty which guides them through the unknown? Is it not rather inequality in the power of flight? I recollected that my Hymenoptera did not all fly off with the same energy; hardly were some out of my fingers, launching themselves impetuously into the air, than I lost sight of them, while others let themselves drop a few paces off after a short flight. It seems certain that these had suffered during the journey—perhaps from the concentrated heat in the furnace of my box, or I may have harmed the jointure of the wings while marking them—an operation difficult to perform when one has to avoid being stung. These are maimed, weak creatures—unable to go on with all sail spread, as they ought, for this journey. The experiment must be tried again, only counting those bees which instantly leave my fingers with a swift, strong flight. We shall omit those which hesitate or linger close by on some bush. Moreover, I will do my best to compute the time employed in returning to the nest.

Such an experiment requires a considerable number of subjects, as the weak and maimed, who may be many, must be rejected. Chalicodoma muraria cannot furnish the quantity needed; it is not common enough, and I am anxious not to disturb the small people by the Aigues whom I want for other observations later. Fortunately I have near my house, under the projecting edge of the roof of a shed, a magnificent

colony of Chalicodoma sicula in full activity. I can draw at pleasure on the populous city. The insect is small—less than half the size of C. muraria; no matter—all the more merit if it can traverse the four kilometres which I have in reserve for it, and find its nest. I took forty, isolating them as usual in paper cones.

A ladder was placed against the wall in order to reach the nest; it was to be used by my daughter Aglaë, to allow her to mark the exact instant when the first one returned. I set the clock on the mantelpiece and my watch together, that I might compare the moment of departure and arrival. Then I carried off my forty captives to the spot where Chalicodoma muraria works beside the Aygues. The expedition had a double scope—to observe Réaumur's mason bee and set the Sicilian one free. The latter would have to fly back four kilometres.

At length my prisoners were released—all marked with a large white dot in the middle of the thorax. It is not for nothing that one successively handles forty wrathful Hymenoptera which forthwith unsheath and make play with their poisoned stings. Before the mark could be made, too often the stab was given, and my burning fingers moved in self-defence sometimes against my will; I handled them with more consideration for myself than for the insect, and sometimes squeezed my bees too hard. To experiment in order to lift a small corner of the veil that covers a truth is a beautiful and noble thing, which can enable one to brave many perils, yet surely one may show a little impatience if in a brief space of time one's finger tips get stung forty times.

If any one should reproach me for my clumsy handling, I would suggest that he make the experiment, and then judge how far the situation was pleasant.

In short, either from the fatigue of the journey, or because I pressed too hard and injured some articulations, out of my forty Hymenoptera only twenty flew off strongly and unhesitatingly; the rest strayed over the herbage near at hand, unable to keep their balance, or remained on the willows where I had put them, refusing to fly even when excited by a straw. These faint-hearted ones, these maimed ones, these incapables hurt by my fingers, must be struck off the list. Twenty started with an unhesitating flight. That was amply sufficient.

At the moment of departure there was nothing special in the direction taken—nothing of that straight line to the nest which the Cerceris took in a like case. As soon as they were free the Chalicodoma fled scared—one in this direction, one to a completely opposite point; but, as far as their fiery flight allowed, I think I saw a rapid return of those bees which had flown in the wrong direction for their nests, and most seemed to go to that side of the horizon. I leave this point with the doubts unavoidable with regard to insects lost sight of at some twenty metres distance. So far the experiment had been favoured by calm weather, but now things grew complicated. The heat was stifling, and the sky grew stormy. Rather a strong wind rose, blowing from the south—the very direction which my bees should take to return home. Could they overcome this contrary current and cleave this aerial torrent

with their wings? If they try it they must keep close to the ground, as I saw those Hymenoptera doing which continued to work, but it appeared out of the question to soar into the high regions where they might obtain a clear acquaintance with the surrounding country. It was therefore with great apprehension as to the success of my experiment that I returned to Orange after again trying to learn some secret from the bees on the Aygues pebbles.

Hardly had I entered my house when I saw Aglaë, flushed with excitement. "Two," she cried—"two came at twenty minutes to three, all laden with pollen!" A friend chanced to have come in—a grave legal personage, who, hearing what was on hand, forgot the Code and stamped paper, and insisted on also watching for the arrival of my homing pigeons. The result interested him more than did the lawsuit about the partition wall. In a Senegalian sun and furnace heat reflected from the wall, every five minutes did he mount the ladder bareheaded, with no other protection against sunstroke than his thick, gray locks. Instead of the single watcher whom I had posted I found two good pairs of eyes watching the bees' return. I had freed them about two o'clock, and the first two returned to the nest at twenty minutes to three, so that three-quarters of an hour had sufficed for travelling four kilometres,—a very striking result, especially if we remember that the bees worked on the road, as was proved by the pollen on their bodies, and besides they must have been hindered by having the wind against them. Two more came back under my eyes, and they had signs of having worked on the way by their load of

pollen. As it was growing late, observations could not be continued. When the sun goes down the mason bees leave the nest and take refuge I know not where—here and there—perhaps under roof tiles and in little shelters in walls. I could not count on the arrival of the others until work was resumed in full sunshine.

The next day, when sunshine recalled the scattered workers, I again counted the bees with white dots on their thorax. My success surpassed all my hopes; I counted fifteen—fifteen of the deported bees storing or building as if nothing had happened! Then the storm, which had threatened more and more, burst, and a succession of rainy days stopped all further observations.

Such as it was, the experiment sufficed. Out of twenty bees which seemed fit for the journey when released, fifteen at least had come back—two in the first hour, and three in the course of the evening, and the rest next morning. They had come back in spite of having the wind against them, and—a yet greater difficulty—in spite of their unfamiliarity with the place whither I had transported them. There could be no question that it was for the first time that they saw the osier beds of the Aygues which I had chosen as the starting-place. Never on their own account had they gone so far afield, for they find all they want by way of building material and food close to my shed. The road at the foot of the wall furnishes mortar; the meadows round my house offer nectar and pollen. Economical of time as they are, they would not fly four kilometres to procure what abounds close to the nests. I see

them daily taking material from the road, and making a harvest on the meadow flowers, especially on Salvia. According to all appearance they do not fly beyond a circle of a hundred metres. How then did my exiles return? What guided them? Not memory, certainly, but some special faculty, which we can only recognise by its astonishing effects without pretending to explain it, so far outside our own psychology is it.

XXII

AN EXCHANGE OF NESTS

LET us continue our series of experiments on Chalicodoma muraria. From its position on a stone which one can move at will, its nest lends itself to very interesting trials. This is the first of them. I change the place of a nest by carrying the pebble it is placed on some couple of yards away. Edifice and base forming but one, the move was made without at all disturbing the cells. I set the pebble in an open place well in sight, as it was before. When the bee returned, she could not fail to see it.

After a few minutes the owner arrived and went straight where the nest used to be. She hovered gently just above the vacant spot, looked, and alighted just where the stone used to lie. There she walked about, searching pertinaciously, then soared up and flew away. Her absence was short; she came back speedily and resumed her search on foot or on the wing—always on the spot formerly occupied by the nest. A new fit of irritation expressed by a sudden flight through the osier bed, then as sudden a return and resumption of the vain search—always

over the impression left by the pebble which I had carried away. These sudden flights, prompt returns, and obstinate examinations of the empty place, were repeated very many times before the mason bee could believe her nest was gone. She certainly must have seen it in its new position, for sometimes she flew only a few inches above it, but she did not care about it. For her it only represented the nest of another bee.

Often the experiment ends without so much as a visit to the stone carried three or four yards away; the bee departs and does not return. If the distance be less—say a yard—sooner or later she alights on the pebble on which her nest is built. She will visit the cell which she was making or storing a little while earlier, plunge in her head several times, examine the surface of the stone narrowly, and after much hesitation return to search over the original spot. The nest, which is no longer in its right place, is altogether abandoned, though it be but a yard away. Vainly does the bee alight on it; she cannot recognise it as hers. I convinced myself of this by finding it several days later in just the same state as when I moved it. The cell, half filled with honey, was still open, allowing the ants to pillage it; the cell in process of construction was unfinished, without a single new course of mortar. Of course the bee may have returned, but she had not resumed her work. The displaced abode was abandoned for ever.

I shall not deduce the strange paradox that a bee, capable of returning home from a great distance, is yet incapable of finding it a yard off; the in-

terpretation of the facts does not involve this. The conclusion appears to be that she retains a tenacious impression of the spot occupied by the nest, returning there with an indefatigable obstinacy when the nest is gone. But of the nest itself she has a very vague notion—does not recognise her own masonry kneaded with her own saliva, nor the honey paste she had collected. Vainly does she visit her work, the cell; she abandons it, not acknowledging it any more, since the place where lies the pebble is no longer the same.

We must own that insect memory is a strange one, so lucid in general knowledge of locality, so limited as to its home. I should be disposed to name it topographical instinct; the creature knows the localities, but not the dear nest—the dwelling. The Bembex led us to a like conclusion. The nest being laid open, she cared nothing for the family—for the larva writhing distressfully in the sun unrecognised. What they do recognise, what they seek, and find with marvellous precision, is the place where no longer exists anything of the entrance door—not even a threshold.

If any doubt remain as to the powerlessness of Chalicodoma muraria to know her nest except by the place which the pebble occupies on the ground, this may set it at rest. I substituted a nest of one mason bee for that of another, as alike as might be, both in masonry and storage. Of course this exchange and those of which I shall speak later were made during the absence of the owner. In the nest not hers, but placed where her own had been, she established herself without hesitation. If she had been building,

I offered her a cell in process of construction, and she worked on with the same care and zeal as if the work already done had been her own. If she were bringing honey and pollen, I offered a cell partly stored. Her journeys continued, with honey in her crop and pollen underneath her body to complete filling the store of another bee.

Thus the bee does not suspect the exchange, nor distinguish what is and is not hers. She thinks she is continuing to work at a cell really her own.

After leaving her for a time in possession of the exchanged nest, I restored her own. The fresh change passed unobserved; her labour was continued in the cell restored to her, at the point at which it had arrived in the substituted one. Then I once more substituted the strange nest, and still she persisted in her labour. Thus alternating nests at the same spot, I thoroughly convinced myself that the insect cannot perceive the difference between that which is her own and that which is not. Whether the cell be hers or not, she works with equal fervour, provided that the basis for the edifice—the stone—remains in its original position.

One may lend a livelier interest to the experiment by using two neighbouring nests—work at which is about equally advanced. I transpose them, placing one where the other was; the distance is hardly a cubit. Despite this close neighbourhood, which allows the bees to see both nests at once and choose between them, the two bees on arriving each immediately alighted on the substituted nest and went on working at it. We may change the two nests at pleasure; we shall still see the two mason bees keep to the

spot chosen by them and work in turn—now at their own cell, now at that of the other.

It may be thought that the confusion was caused by a close resemblance between the two nests, since, at first little expecting the results obtained, I began by choosing those as much alike as possible, lest the bees should be repelled. My caution presupposed a clear-sightedness the insect did not possess. I now took two nests exceedingly unlike, except that in each the bee found a cell advanced in its work to the same point. The first was an old nest, with the dome pierced with eight holes, the orifices of cells of a preceding generation; one of these had been restored, and the bee was storing it. The second was a new nest, with no dome, and composed of a single cell with little stones on the outside. Here too the bee was storing her paste. Certainly no two nests could differ more: the one with its eight vacant rooms, and its ample dome of clay, the other with a single cell—bare, and at most the size of an acorn.

Well, the two mason bees did not hesitate long before the two exchanged nests—hardly a yard apart. Each went to the site of its former abode. The owner of the old nest found but a single cell. She rapidly inspected the stone, and without further ceremony first plunged her head into the cell to disgorge honey, and then her hind-quarters to drop pollen. And this was no action performed to rid herself as soon as possible of a trying burden, for she flew away and quickly returned with fresh stores to be laid up. This bringing provisions to another's larder was repeated as often as I would allow. The other bee, finding, instead of one cell a spacious building

with eight chambers, was at first considerably embarrassed. Which of the eight was the right one?—in which was her heap of bee bread? She plunged down into each room, and at length found what she was seeking—a condition like that which she had left when she took her last journey, the beginning of a store of food. From that moment she behaved like her neighbour, and carried honey and pollen to a cell not made by her.

Let us restore the nests to their natural places, exchanging them afresh. Each bee, after a little hesitation, sufficiently explained by the very great difference between the two nests, will work alternately in her own cell and the strange one. At length the egg is laid and the cell closed, whichever the nest may be that she is occupied with at the moment when the provisions are sufficient. Such facts show clearly why I hesitate to give the name of memory to the singular faculty that brings back the insect so accurately to the site of her nest, yet does not allow her to distinguish her work from that of another, however great may be the difference of appearance between them.

Now let us experiment on Chalicodoma muraria from another psychological point of view. Here is a mason bee at work on the first course of her cell; in exchange I give her one not only completed, but half full of honey, which I stole from an owner who would speedily have laid an egg there. What will the mason do with this munificent gift which spares her the labour of building and storage? Leave her mortar, of course, lay an egg, and close all up. Not at all! the animal finds our logic illogical. The insect

obeys an inevitable, unconscious impulse. It has no choice as to what it shall do,—no discernment as to what is and is not desirable,—but glides, as it were, down an irresistible slope prepared for it beforehand to bring it to a determined end. The facts still to be stated affirm this strongly.

The bee, which is building, and to which I offer a cell ready made and full of honey, will not give up building for that; she is following her trade as mason, and once on that tack, led on by unconscious impulse, she must needs build, even if her labour be superfluous and contrary to her interests. The cell I give her is certainly quite complete in the opinion of its own constructor, since the bee from whom I subtracted it was finishing the store of honey. To touch it up, and, above all, to add to it is useless and absurd. All the same the bee which is building will build. On the orifice of the honey store she lays another layer of mortar, then another and another, until the cell is actually a third beyond its usual height. Now the task is done—not as well indeed as if the bee had continued the cell whose foundations she was laying when the nests were exchanged, but certainly in a way more than enough to demonstrate the irresistible impulse which drove the builder on. Then came the storing, likewise abridged, for otherwise the honey would overflow by the union of the stores of two bees. Thus the mason bee, which is beginning to build, and to which one gives a cell completed and filled with honey, alters nothing in the order of her work. First she builds and then she stores; only she shortens her labours—instinct warning her that the height of the

cell and quantity of honey are beginning to assume proportions too great.

The reverse of this is not less conclusive. To a mason bee which was laying up food I would give a cell only just sketched out and unable to receive the honey paste. This cell, still damp from the constructor's saliva, might or might not be accompanied by other cells, recently closed and containing an egg and honey. The bee, whose half-filled cell is thus replaced, seems greatly puzzled on arriving with her load at this shallow hollow offering no place for the honey. She will examine it, measure it with her eye, try it with her antennæ, and recognise its insufficient depth. For a time she hesitates, departs, returns, flies off again, and comes back in haste to dispose of her load. Her embarrassment is visible; I could not help saying inwardly: "Take some mortar—take some mortar, and finish your storehouse. It will only require a few moments to make it deep enough." The bee was of a different opinion. She was laying in food, and food she must lay up, happen what might. She could not decide to lay aside the pollen brush for the mason's trowel, and nothing could induce her to delay the harvest which occupied her in order to take up that work of building for which it is not the due moment. Rather would she seek another cell, in the desired condition, and will penetrate there to store the honey, even if received with fury by the owner. In fact, this happened. I wished her success, knowing myself to be the cause of this desperate act. My curiosity had turned an honest worker into a thief.

Matters may take a yet more serious turn, so

obstinate and imperious is the desire to harvest the store securely. The unfinished cell that the bee refuses to accept instead of her own complete one, with its honey, is sometimes, as I have said, among several containing paste and egg, and newly closed. In this case I have seen, though not always, the following sight. Having ascertained unmistakably that the unfinished cell will not do, the bee begins to gnaw the cover of a neighbouring one. With her saliva she softens a spot in the mortar, and patiently digs away atom by atom in the hard covering. A long half hour passes before the tiny dimple excavated is big enough to receive a pin's head. I waited. Then I got out of patience, and, feeling sure that she wanted to open the storehouse, I decided to help her and shorten the labour. With the point of my knife I knocked off the top; but the crown of the cell came off too, and its edge was a good deal broken. In my clumsiness I had made a graceful vase into a wretched, shattered pot. I was right; the bee wanted to break open the door, and without troubling herself as to the fragmentary state of the orifice, she immediately established herself in the cell opened to her. Many times did she bring honey and pollen, though the store was already complete. Finally, in this cell containing an egg not hers she laid her own egg, and then closed, as best she could, the shattered mouth. Thus this bee, who was engaged in bringing food, neither could nor would be baffled by the impossibility brought about by me of continuing her work unless she completed the cell which replaced hers. What she was doing she persisted in doing in spite of obstacles. She accomplished her task thoroughly, but in the

most absurd way,—by breaking into another bee's cell, continuing to store in a cell already overflowing, placing an egg where the real owner had already laid one, and finally, closing an orifice which needed serious repairs. Could one desire a better proof of the irresistible impulse obeyed by the insect?

Finally, there are other rapid and consecutive actions so closely connected that the execution of the second implies necessarily the repetition of the first, even when this has become useless. I have already said how Sphex flavipennis persists in going down into her burrow alone, having brought near it the cricket which I cruelly removed immediately. Her repeated discomfitures did not make her give up the preliminary domiciliary visit, useless as it is when repeated ten or twenty times. Chalicodoma muraria exhibits under another form a like repetition of an act useless itself, but a necessary prelude to the next one. Arrived with her booty, she goes through a double act of storage. First she plunges head first into the cell to disgorge the contents of her crop; then she comes out, returning at once backward to brush off her load of pollen. At the moment when she is about to enter, tail first, I gently put her aside with a straw, thus hindering her second action. She begins all over again, going head first into the cell, although her crop is empty. Then comes the turn of going in backward. I instantly put her aside again, and again she goes in head first. Once more I use my straw. And this goes on as long as the observer pleases. Put aside just as she is about to introduce her hinder parts into the cell, she returns to the orifice and persists in

descending head first. Sometimes she goes quite down—sometimes only half-way, or perhaps there is a mere pretence at descending, and she only stoops her head in the opening, but at anyrate this quite useless action—for the honey is already disgorged—invariably precedes the entrance backward to deposit pollen. It is almost the movement of a machine, not a wheel of which moves till the main one begins to turn.

DESCRIPTIVE NOTES

THE following Hymenoptera appear new to me in the French fauna. I append their description:—

Cerceris antoniæ, H. Fab.

Length—16-18 millimetres. Black, closely and strongly punctured; clypeus raised like a nose, *i.e.* forming a convex projection, large at the base, pointed at the end—like half a cone cut down its length; crest between the antennæ projecting; a line above crest, cheeks, and a large dot behind each eye, yellow; hood—yellow with black point; mandibles, rusty yellow; tips, black. The 4th and 5th joints of antennæ, rusty yellow, the rest brown. Two dots on prothorax, wing scales and postscutellum, yellow; first segment of abdomen with two dot-like spots; four next on posterior edge having a yellow band sharply hollowed in triangle form, or even broken, and this the more as the segment is a less distant one.

Under part of the body, black; feet entirely of rusty yellow colour; wings slightly bronzed at tip. Female. Male unknown to me.

In colouring this species approaches Cerceris labiata, from which, however, it differs remarkably in the form of the clypeus and the much larger size of the insect. Observed round Avignon in July. I dedicate this species to my daughter Antonia, whose help has often been valuable to me in my entomological researches.

Cerceris julii, H. Fab.

Length—7-9 millimetres. Black, closely and strongly punctured; clypeus flat; face covered with a fine silvery pubes-

cence; a narrow yellow band on each side, on the inner edge of the eyes; mandibles—yellow with brown tips; antennæ—black above, pale red below; lower face of their basal joint, yellow. Two small distant points on the prothorax; scales of wings and postscutellum, yellow. A yellow band on third segment of the abdomen, and another on the fifth; these two are deeply hollowed on the anterior edge—the first in a semicircle, the second in a triangle.

Under part of the body all black; coxæ black; thighs of the hinder pair of legs quite black; those of the two anterior pairs, black at base, yellow at the ends; legs and tarsi, yellow; wings rather smoke-coloured. Female.—Var. (1) Prothorax without yellow dots; (2) two small yellow dots on second segment of abdomen; (3) wider yellow band on inner side of the eyes; (4) front of clypeus edged with yellow.

Male unknown to me. This Cerceris, the smallest of my part of France, feeds its larvæ on the smallest kinds of weevils (Bruchus granarius and Apion gravidum). Observed round Carpentras, where it builds in September in soft sandstone—locally called *safre*.

Bembex julii, H. Fab.

Length—18-20 millimetres. Black, with bristling whitish hairs on head, thorax, and base of first segment of the abdomen; labrum lengthened, yellow; clypeus, with a sloping ridge, forming as it were an angle of three sides—one face—that of the outer edge—is all yellow, while each of the two others is marked with a large rectangular black patch bordering on its neighbour, and thus forming a stripe; both marks, as well as the cheeks, are covered with a fine silvery down; cheeks on line between the antennæ, yellow; posterior edge of eyes with a long yellow border; mandibles—yellow, with brown tips; two first joints of antennæ yellow beneath, black above, the rest black; prothorax—black; sides and dorsal division, yellow; mesothorax—black; the callous point, and a small one on each side above the base of the intermediate feet, yellow; metathorax—black, with two yellow dots behind, and a larger one on each side above the base of the hind feet. The two first dots are sometimes wanting.

Abdomen—bright black above and without hairs, except at

the base of the first segment, which bristles with whitish ones. All the segments have a wavy transverse band, wider on the sides than in the middle, and approaching the posterior edge in proportion as the segment is further back. On the fifth segment the yellow band reaches the posterior edge. Anal segment—yellow, black at the base, bristling all over the dorsal surface with papillæ of a rusty red, which serve as base to the hairs. A row of like hair-bearing tubercules occupies also the posterior edge of the fifth segment. Below, the abdomen is a brilliant black, with a triangular yellow mark on each side of the four intermediate segments.

Coxæ—black; thighs yellow in front, black behind; legs and tarsi—yellow; wings transparent.

Male.—The zig-zag mark on the clypeus is narrower, or even absent; face then entirely yellow; abdominal bands very pale yellow, almost white. The sixth segment has a band like the preceding ones, but shorter and often reduced to two dots. The second segment has underneath it a longitudinal keel, raised and spine-shaped behind. The anal one has below it an angular, rather thick projection. Otherwise like the female.

This Hymenopteron much resembles Bembex rostrata in size, shape, and arrangement of the black and yellow colouring, but differs markedly in the following characteristics:—The clypeus makes a triangle of three sides, while in other Bembecids it is rounded and convex. Also at the base is a large zig-zag band, formed by two rectangular marks joined together and softened by a silvery down, very brilliant under certain lights. The upper surface of the anal segment bristles with papillæ and reddish hairs—likewise the further edge of the fifth segment. The mandibles are only black at the tips, while in Bembex rostrata the base is also black. Their habits are equally unlike; B. rostrata especially hunts gadflies, while B. julii never catches large Diptera, but takes smaller kinds of very varying size. It is frequent in the sandy land of the Angles, round Avignon, and on the hill of Orange.

Ammophila julii, H. Fab.

Length—from 16-22 millimetres. Stalk of abdomen composed of the first segment and half the second; third cubital

narrowed towards the radial; head—black, with silvery down on the face; antennæ—black; thorax—black, with transverse stripes on its three segments, darker on prothorax and mesothorax. Two marks on the sides and one behind either side of the metathorax, covered with silvery down; abdomen bare, shining. First segment—black; second—red in the part narrowing to the petiole and in the widened part; third segment all red; the rest of a beautiful metallic blue. Legs—black, with silvery down on the coxæ; wings slightly reddish. Builds in October, and lays up two smallish caterpillars in each cell. Nearly related to A. holosericea, having the same shape, but differing markedly in the colour of the legs, which are all black, by the much less downy head and thorax, and by the transverse stripes on the three segments of the thorax.

I wish these three Hymenoptera to bear the name of my son Jules, to whom I dedicate them.

Dear child! snatched so early from thy passionate love of flowers and insects! Thou wert my fellow-worker; nothing escaped thy clear-sighted glance; it was for thee that I was to write this book—for thee, to whom its recital gave such delight, and thou wert one day to have continued it. Alas! thou didst leave us for a better home, having heard but the first few lines of the book. But at least let thy name appear in it—borne by some of these industrious and beauteous Hymenoptera so dear to thee!

J. H. F.

ORANGE, *3rd April* 1879.

THE END

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